REPORT

OF THE

INTERDEPARTMENTAL COMMITTEE

ON

RESEARCH AND DEVELOPMENT IN THE DEPENDENCIES OF THE FALKLAND ISLANDS,

WITH

APPENDICES, MAPS, &c.

Presented to Parliament by Command of His Majesty.

April, 1920.

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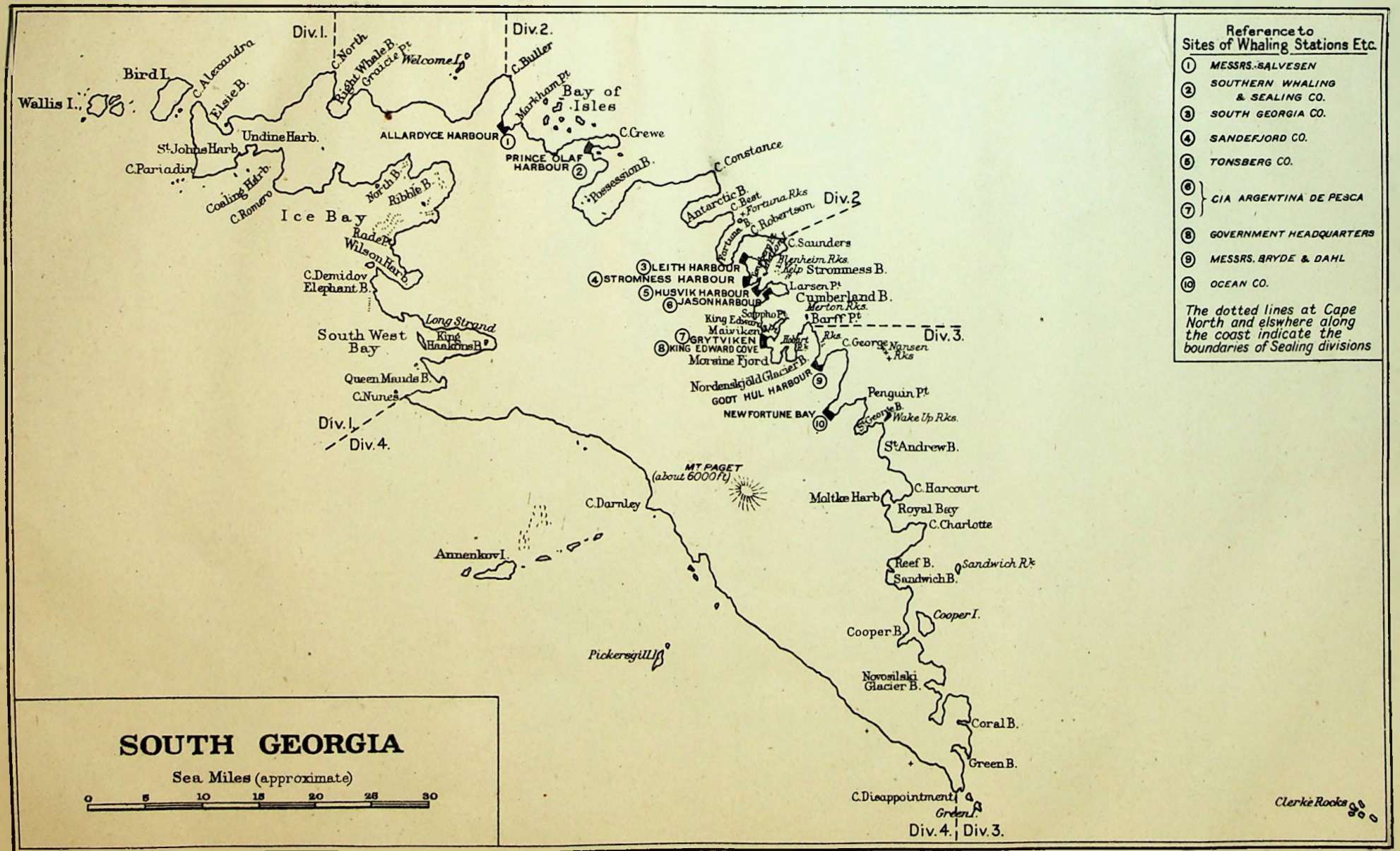

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REPORT OF THE INTERDEPARTMENTAL COMMITTEE ON RESEARCH AND DEVELOPMENT IN THE DEPENDENCIES OF THE FALKLAND ISLANDS.

PART I.—INTRODUCTION.

(*a*) *The Appointment of the Committee.*

1. IN the year 1917 attention was drawn to the question of the development of the Dependencies of the Falkland Islands in several memoranda prepared by Mr. E. R. Darnley, of the Colonial Office, and submitted to the Secretary of State for the Colonies. In August of the same year the Colonial Office addressed the Lords Commissioners of the Admiralty on the subject, with special reference to the preservation of the whaling industry and the possibility of the development of other industries. With the letter was forwarded a note on the economic resources of this area and a memorandum by Dr. R. N. Rudmose Brown, of the Scottish National Antarctic Expedition, discussing a proposal made by the Colonial Office for the despatch of a research vessel for the study of whales and whaling. It was pointed out in the letter that excessive hunting had resulted in the collapse of the whaling industry in the Greenland and Spitsbergen waters, and that the information as to conditions in the southern hemisphere was at present insufficient to warrant a final decision whether there was any danger of a similar collapse of the whaling industry in the Dependencies of the Falkland Islands. It was further suggested that the investigations of a research expedition in that area might include hydrography, meteorology, geology, magnetism, and tidal work. It was noted that the Governments of India, Egypt, and the Union of South Africa might be interested in such investigations, especially in those relating to meteorology, and the letter recalled the fact that, out of half a dozen fully-equipped scientific expeditions that had worked in these regions, only one had been British, and that at the present time the actual whaling was carried out almost entirely by Norwegians. Copies of the letter were sent to various Departments likely to be interested in the subject, including the Natural History Departments of the British Museum.

2. The general proposals made in the letter met with a cordial response from the Admiralty and the British Museum, and the other Departments addressed, and Mr. Secretary Long eventually constituted a Committee for the Dependencies of the Falkland Islands to advise him on the whole subject, with the following members :—

Mr. J. O. Borley, O.B.E., of the Board of Agriculture and Fisheries.
Mr. E. R. Darnley, of the Colonial Office.
Dr. S. F. Harmer, Sc.D., F.R.S., of the British Museum (Natural History).
Mr. P. C. Lyon, C.S.I., of the Department of Scientific and Industrial Research.
Captain C. V. Smith, C.B.E., R.N., of the Admiralty.

with Mr. H. T. Allen, of the Colonial Office, as Secretary.

3. The terms of reference to the Committee, as finally laid down after the Committee had considered them at its first meeting, were :—

> "To consider what can now be done to facilitate prompt action at the conclusion of the War in regard to the preservation of the whaling industry and to the development of other industries in the Dependencies of the Falkland Islands; and to consider not only the economic questions above referred to, and the scheme for the employment of a research vessel, but also what purely scientific investigations are most required in connexion with these regions, and whether any preliminary inquiries by experts in this country should be instituted."

4. Mr. P. C. Lyon was elected Chairman of the Committee at its first meeting.

(*b*) *Area of the Dependencies.*

5. A map of the area with which the Committee was thus called upon to deal is appended to this report. It consists of the land between longitude 20° W. and 50° W. south of latitude 50° S., and between longitude 50° W. and 80° W. south of latitude 58° S. These boundaries include a sector of the Antarctic land area to the south and south-east of Cape Horn, a considerable number of islands

in the Southern Ocean, and also more than a million square miles of sea readily accessible for whaling, fishing, and sealing, the total area amounting to about three million square miles, or one-and-a-half per cent. of the whole surface of the globe.

6. The principal lands and islands are :—

South Georgia.
The South Shetland Islands.
Graham Land, with the islands adjacent to it.
The South Orkney Islands.
The South Sandwich Islands.

The area comprises the only Antarctic or sub-Antarctic regions containing good harbours open all the summer, and, in the case of South Georgia, open all the year round, and the only such region in which any industry exists. Storms of exceptional severity are frequent, and the temperature, which is extremely low throughout the winter, rarely reaches 40° Fahr. even in the summer months. The whaling field within the Dependencies is of greater importance than all the others in the world combined. It is worked by several companies, the majority of which are Norwegian, one is Argentine, and two are British. One of the British companies is, however, by far the largest of all. But the managers, sailors, and other employees of all companies alike are almost exclusively Norwegian.

(c) History, Situation, and Physical Characteristics.

7. *South Georgia* is an island about a hundred miles in length, with a maximum breadth of twenty miles. It is situated approximately nine hundred miles east by south of the Falkland Islands. Its discovery has been variously attributed to Amerigo Vespuccio (1501-2) and Anthony La Roche (1675), but the island was not explored until Captain Cook took possession of it in 1775. It consists mainly of steep mountains, from which glaciers descend. There is but little flat land, and the island is almost entirely barren, the south-west side being permanently frozen. The main vegetation is some coarse grass which grows on the north-east side of the island in patches where the snow melts in the summer. There are no indigenous quadrupeds other than seals, but reindeer have been introduced and are thriving well. There are many sea birds, including penguins and albatrosses. The sea-elephant, the sea-leopard, and Weddell's seal frequent its coast. The shore has been indifferently charted, but there are some good harbours. The island is an important centre of the whaling industry, several land factories for treating the carcasses of captured whales having been set up on it.

8. *The South Shetland Islands* comprise a considerable number of small islands about four hundred miles south-east of Cape Horn. They were discovered in 1819 by Captain William Smith, who landed on King George Island and took possession for Britain. The islands are permanently frozen and barren, but there are several good harbours, open during the summer months, including the landlocked harbour of Deception Island, the entrance to which is only about two hundred yards wide. The roadstead of this harbour is from five to six miles wide and has a depth of ninety-seven fathoms at its deepest part. It possesses only one ice-free beach, due to the presence of hot streams. There is much whaling carried on round the islands, but there is only one shore station situated at Deception Island. The whale-catchers are accompanied by larger vessels used as floating factories.

9. *Graham Land* is a high mountainous region, with several adjacent islands, lying south of the South Shetlands and between latitude 60° and 70° S. Graham Land is covered with a thick layer of ice and snow, which moves slowly down to the coast, where it usually terminates in a lofty cliff or ice barrier of the ordinary Antarctic type. Landings are difficult, and few have been made, except in the Orleans Channel. A good harbour, Port Lockroy, is to be found at Wiencke Island. Graham Land was taken possession of by Captain Biscoe in 1832.

10. *The South Orkneys* lie about two hundred miles east of the South Shetlands. The two principal islands are Laurie Island and Coronation Island, the latter of which is thirty miles long by twelve miles broad, and the former twenty-six miles long with a breadth varying from half a mile to eleven miles. Captain George Powell landed and took possession of these islands in 1821. The

roadsteads are poor, and but little whaling has been done in their neighbourhood. The Argentine Republic, with the permission of His Majesty's Government, maintains a meteorological station on Laurie Island.

11. *The South Sandwich Islands* form an inhospitable string of some sixteen volcanic rocks about two hundred miles in length, lying between two hundred and fifty and three hundred miles south-east of South Georgia. Some of these rocks are active volcanoes. There is said to be a good harbour in one of these islands, Southern Thule, but it is nearly always icebound, and is not used by whalers. The group was discovered by Captain Cook in 1775.

(*d*) *Government.*

12. The Government of the Dependencies is administered by the Governor of the Falkland Islands, who is empowered by letters patent to make laws for the Dependencies by and with the advice and consent of the Legislative Council of the Falkland Islands. The Executive Council of the Dependencies consists of such persons as from time to time constitute the Executive Council of the Falkland Islands. Ordinance No. 9 of 1908 of the Legislature of the Falkland Islands provides for bringing the laws of the Colony into force in the Dependencies, but no Ordinance of the Colony applies to the Dependencies unless expressly declared by notification in the Falkland Islands *Gazette* to be in force there. Also any Ordinance of the Colony which applies to the Dependencies is in force there so far only as the local circumstances permit and subject to such qualifications as those circumstances render necessary. The jurisdiction of the Supreme Court of the Colony applies to the Dependencies; and the Governor is empowered to appoint such magistrates and other officers as may be necessary. Apart from the staff of the meteorological station at Laurie Island, South Orkneys, South Georgia is the only Dependency which is permanently inhabited; the island being the seat of a whaling industry which is carried on all the year round. The establishment provided by the Government at South Georgia consists of a Stipendiary Magistrate, two Customs officers, and a police constable. A magistrate accompanies the whaling expeditions which proceed annually to the South Shetlands and Graham Land during the summer months; and a representative of the Government used to proceed to the South Orkneys with the expeditions to that Dependency. No whaling operations have, however, been carried on in the neighbourhood of the latter islands since 1914-15. The revenue and expenditure of the Dependencies are respectively paid into, and met from, the general revenue of the Falkland Islands. In 1917, the last year for which complete figures are available, the actual receipts from the Dependencies amounted to £15,366, while the purely local expenditure amounted to only £776. To this latter figure there should, however, be added a share of the cost of the central administration.

(*e*) *Scientific Expeditions.*

13. A bibliography, which, however, does not purport to be exhaustive, will be found in Appendix XXVII.; and an account of the earliest voyages of exploration in the area of the Dependencies of the Falkland Islands is given by Dr. Bruce in the letter printed as Appendix I. In 1829 pendulum and gravity observations were carried on for some months at Deception Island, South Shetlands, by H.M.S. "Chanticleer" (Captain Henry Foster, R.N.). The "Erebus" and "Terror," which were sent out to the Antarctic by the British Government under the command of Captain (afterwards Sir) James Clark Ross, R.N., and were primarily intended to carry out magnetic surveys, visited the area of the Dependencies in 1843. On the 16th February, 1874, the Antarctic circle was crossed for the first time under steam by H.M.S. "Challenger" in the course of her famous cruise. In 1873-4, Captain Dallmann, of the German whaler "Grönland," visited the South Shetlands, South Orkneys, and Graham Land and carried out surveys. Magnetic and meteorological work was carried on by German observers at Royal Bay, South Georgia, in connexion with the international circumpolar observations, 1882. In 1892 the "Balæna," "Active," "Diana," and "Polar Star," of the Dundee whaling fleet, visited these waters. In the same season Captain C. A. Larsen also arrived on the "Jason." He returned to these regions in 1893-94 on that vessel, accompanied by the "Hertha" and "Castor." These three expeditions were primarily

intended to ascertain the possibilities of whaling and sealing; but Dr. Bruce and Dr. Donald, the respective naturalists and surgeons of the "Balæna" and the "Active," were provided with some scientific equipment, and Mr. W. G. Burn Murdoch made a series of artistic records of scientific value. The purely scientific expeditions which subsequently visited these regions include:—

(*a*) The Belgian expedition (1898-9), organized and led by Adrien de Gerlache in the "Belgica," accompanied by a scientific staff. This expedition was the first organized on modern principles; and the "Belgica" was the first vessel to winter in the Antarctic. The two shores of Gerlache Strait and the islands within it were surveyed, and scientific observations of all kinds were taken, and rich collections in natural history were obtained. The expedition ascended the west coast of Graham Land and reached the neighbourhood of Alexander I. Land.

(*b*) The Swedish expedition (1901-3), led by Dr. Otto Nordenskjöld in the "Antarctica" (Captain C. A. Larsen). The expedition proceeded mainly to the east coast of Graham Land and a shore party wintered on Snow Hill Island, about latitude 64° S. The "Antarctica" was lost in the ice while returning south in the summer of 1902-3 to pick up the winter party, but those on board managed to escape. In 1903 the main party wintered on Snow Hill Island. One ship party wintered at Hope Bay towards the north of Graham Land, and the remaining party from the ship wintered on Paulet Island. All these parties were rescued in November, 1903, by the Argentine warship "Uruguay." Dr. Nordenskjöld's expedition did important survey, zoological, and geological work, but only a small part of the collections were saved. The expedition made eighteen landings in the Orleans Channel and de Gerlache Strait on the west coast of Graham Land.

(*c*) In 1902-4 the Scottish National Antarctic expedition in the "Scotia," under the leadership of Dr. W. S. Bruce, besides other important scientific work, carried out many deep sea soundings and dredgings, and temperature and salinity work in the Weddell Sea and discovered Coats Land, following its coast for one hundred and fifty miles. This expedition wintered in the South Orkneys, carrying out important hydrographical survey work, and established the meteorological station on Laurie Island.

(*d*) Dr. Charcot's first expedition (1903-5), in the "Français," carried out extensive exploration on the west coast of Graham Land between latitude 63° and 67½° S., and discovered a good harbour, Port Lockroy, in Wiencke Island, and a tolerable shelter at Port Charcot in Booth-Wandel Island.

(*e*) Dr. Charcot's second expedition of 1908-10, in the "Pourquoi Pas?" covered a wider range and made important discoveries. The expedition visited the South Shetlands, proceeded along the coast of Graham Land, and as far west as Peter I. Island, i.e., past 90° W. longitude. It wintered in a harbour in Petermann Island. Adelaide Island was measured and accurately placed; Alexander I. Land was shown to be an island; and new land, called Charcot Land, was discovered farther south, about latitude 70° S. and longitude 74°-75° W. This expedition did much important hydrographic work from the South Shetlands and along the coast and among the islands of the west of Graham Land.

(*f*) Sir Ernest Shackleton's expedition, which left this country in 1914, was wrecked, and escaped in 1916 at Elephant Island, one of the South Shetland group, and to South Georgia.

(*f*) *Scope of the Inquiry.*

14. In the correspondence which preceded the appointment of the Committee special stress was laid on the economic objects of the proposed research expedition as constituting its primary mission, and this has helped to determine the scope of of our inquiries and the arrangement of our report. The first subject dealt with, and the one to which we have devoted the greater part of our time, has been the whaling industry; the present state of scientific knowledge concerning it and the researches required to supplement that knowledge; the control to be exercised over it; the economic questions connected with its products, which include whale oil, whalebone, whale meat, and guano; and the present condition of the industry, including the prospects of the more extended employment of British labour in it. Similar inquiries have also been instituted in connexion with sealing, with special reference to the preservation of the sea-elephant and the restoration of the fur seal industry.

15. While the above investigations include much biological work of a purely scientific nature which is closely interwoven with the economic questions affecting the whaling and sealing industries, there are also biological researches of value to be undertaken in connexion with the penguins and other animals found in the Dependencies, and with the marine botany of the area, and its fisheries. And the other subsidiary objects of the expedition, such as hydrography and hydrology, meteorology and magnetism, geology and mineralogy, have also been considered and are dealt with in the course of this report.

16. Finally we have consulted Dr. W. S. Bruce and other experts in the matter of the construction and equipment of the research vessel or vessels to be sent out, the probable cost of the expedition, the staff to be appointed for it, and the management and control of the investigations which are to be undertaken.

(*g*) *The Procedure of the Committee.*

17. The Committee has met twenty-one times. At the first meeting the work to be taken up was reviewed and the procedure for dealing with it was determined. The general plan adopted has been to obtain memoranda from acknowledged experts on the principal subjects of inquiry, and then discuss those memoranda with their authors. The memoranda, with a brief report of the evidence thus taken, will be found in the appendices to this report. We have also had the advantage of seeing the evidence recorded by a previous Committee which began an investigation into the condition of the whaling industry before the outbreak of the War, and we have been permitted to incorporate, as Appendix XIII. to this report, a valuable note on this subject by Dr Hjort, formerly Director of Fisheries, Norway.

18. In view of the great experience and knowledge possessed by Dr. W. S. Bruce, the leader of the Scottish National Antarctic Expedition, in all matters relating to the Antarctic regions, his assistance was sought by the Committee from the outset, and he was the first authority to prepare a memorandum for us and to give evidence. Captain C. A. Larsen and Captain Th. Sörlle were deputed by the Norwegian Union of Whaling Companies to give us the benefit of their experience, and have contributed materially to the information placed at our disposal. We desire to return our cordial thanks to these gentlemen for their ready assistance, and also to the Right Honourable Lord Rothschild, Sir Napier Shaw, Sir Frank Dyson, Dr. G. H. Fowler, Dr. S. Chapman, Dr. Rudmose Brown, Mr. T. E. Salvesen, Mr. Holman Kingdon, Dr. J. W. Evans, Mr. J. F. N. Green, Sir Charles Close, Mr. Einar Lea, and Mr. R. C. Mossman for the valuable information they have given to the Committee in notes, memoranda, or oral evidence. Mr. H. T. Allen, the Secretary to the Committee, has also compiled much information of value for the assistance of the members.

Part II.—The Whaling Industry.

(*a*) *Description of the Industry.*

19. In the Dependencies of the Falkland Islands the Empire possesses a whaling field which has been in recent years more productive than all those in the rest of the world combined.

20. Whaling by modern methods was first carried on in these Dependencies by the Compania Argentina de Pesca, which began operations at South Georgia in December, 1904, and was subsequently granted, as from the 1st January, 1906, a lease of Grytviken Harbour for the establishment of a whaling station. The first modern whaling expedition to the South Shetlands was that of Mr. Alexander Lange, which worked in that Dependency during the season 1905-6. From 1909 to 1911 seven other leases were granted at South Georgia. Meanwhile the number of floating factories employed at the South Shetlands went on increasing, and a whaling lease was granted at Deception Island. Owing, however, to the lack of convenient sites and to the extended area over which whaling is carried on in the South Shetlands, it has not been practicable to establish any shore station except that at Deception Island, and the bulk of the whaling in this Dependency continues to be carried on by floating factories. An additional lease at South Georgia has been promised in consideration of war services. All the leases are

for twenty-one years, and all the licences are annual. In 1911-12 a whaling expedition visited the South Sandwich Islands, but the result was a failure. In the same year whaling was begun at the South Orkneys, and continued with poor success up to 1914-15, when it was abandoned, and has not yet been resumed.

21. The whaling enterprises in South Georgia and the South Shetlands, however, were very successful. In 1912-13 the number of whale catchers employed in South Georgia had risen to twenty-one, and in the South Shetlands to thirty-two, to which figures the whalers were restricted by Government action intended to limit the destruction of whales. Two floating factories were in use at South Georgia and twelve at the South Shetlands, and in addition a number of transport vessels were employed to take out coal and stores to the shore stations and bring home the oil, guano, and other products.

22. During the War whale oil became of great importance as a source of glycerine, Government restrictions were relaxed, and the number of whale catchers allowed at South Georgia was temporarily increased to thirty-two. Meanwhile, however, floating factories had been diverted to war services elsewhere, and the number of whale catchers employed at the South Shetlands had fallen off. Moreover, the whaling fleet had sustained heavy losses from German submarines. Although the number of whale catchers allowed for the season 1919-20 is twenty-seven in South Georgia and thirty-five in the South Shetlands, the actual numbers which are likely to be employed are considerably less. Owing to tonnage difficulties several years will probably elapse before whaling in the South Shetlands can be carried out upon the scale existing at the outbreak of War.

23. The great majority of the whales caught are blue, fin, and humpback whales. The number of humpback whales caught is now comparatively small, while the number of blue whales is usually slightly greater than that of fin whales. The yield of oil is about seventy-five barrels for the blue whale, forty-five for the fin whale, and thirty for the humpback.

24. The principal products of the industry are whale oil, guano, and coarse whalebone. Of these the whale oil is by far the most valuable. In the nine years from 1909-10 to 1917-18, 1,992,000 barrels were produced in South Georgia, 1,136,000 barrels in the South Shetlands, and 130,000 barrels in the South Orkneys. A barrel contains forty gallons, and six barrels contain approximately one ton of oil. The production in 1909-10 was 253,000 barrels, and rose to a maximum of 564,000 barrels in 1915-16, declining to 258,000 barrels in 1917-18. The aggregate value during the nine years, according to the local conventional customs valuation, is between ten and eleven millions sterling, but that valuation was not much altered during the War, although the price of whale oil in the United Kingdom rose by degrees to £62 10s. a ton. Making allowance for this, the aggregate value is over twenty millions. But figures based on exceptional war prices are of little service in attempting to gauge the future importance of the industry. The corresponding figure for guano is only about a quarter of a million, and that for whalebone, so far as recorded, is less than £100,000.

25. As regards the nationality of the firms engaged in the industry, there are thirteen Norwegian companies, of which four are worked as two pairs, so that the number of independent concerns appears to be eleven; three British companies, corresponding to two independent firms; and one Argentine company. The distribution of the industry among these nationalities may be better gauged by the numbers of whale catchers which their companies are authorized to employ. On this basis the present numbers are: Norwegian, thirty-seven; British, seventeen; Argentine, four. This takes no account of the unremunerative whaling field at the South Orkneys.

The British companies work from British ports with British vessels and stores, and to some extent with British plant. Most of the special articles required for whaling were of Norwegian manufacture before the War, but during the War some of these articles, such as whaling lines and "foregoers."* have been produced in Great Britain with some success.

The capital of the British companies is almost entirely British.

* A "foregoer" is that part of a whale-line which is attached to the harpoon, and requires to be stronger and more pliable than the remainder of the line.

While the crews of the transport vessels of British ownership are also British, there is no British personnel possessing the special skill and experience required either for the capture of the whales or for the utilization of the carcasses. The men employed for these purposes, including the staffs of land stations and floating factories, the crews of the latter, and the gunners and crews of the whale catchers, are almost all Norwegian. Some unskilled labour has been engaged in South America, but has proved unsatisfactory, and is likely to be replaced by Norwegian.

(b) Regulation of the Industry.

26. The control of the industry by the Government of the Falkland Islands has been made possible by the fact that, although most of the whales are caught outside territorial waters, they cannot be commercially utilized without the employment of harbours. The main objects of the control exercised by the Colonial Government are to conserve the industry by limiting the number of whale catchers allowed to hunt whales, to prevent the destruction of whale calves, either directly or indirectly, through the killing of nursing mothers, and to minimize waste in the manufacture of the carcasses. The Colonial Government has derived some revenue from rents, licence fees, and taxation of whale oil.

27. The efforts of the Colonial Government to minimize waste have been hampered by the terms of four of the earlier South Georgia leases, which contain no covenant to utilize the whole carcass; and upon floating factories the utilization of the whole carcass, and particularly the manufacture of guano, has not hitherto been commercially practicable. The regulations as regards floating factories have accordingly been directed to secure that adequate plant, in the form of pressure boilers, is provided for the extraction of oil from the meat, and not merely from the blubber.

28. We are informed that, subject to the foregoing limitations, the control of the industry by the Colonial Government has been fully effectual. It is stated that the regulations are carefully observed by the companies, and that no serious case of infringement has occurred.

29. During the War the marketing of the oil has also been temporarily controlled.

30. Details regarding the rise, extent, production, and regulation of the industry will be found in Appendices V. and XI.

(c) Species of Whales captured.

31. A memorandum on the southern species of whales will be found in Appendix VIII. The questions (i) whether the southern whales are specifically identical with their northern representatives , and (ii) whether definite races are to be distinguished among the southern species, need further investigation. For practical purposes it may be assumed provisionally that the southern forms are not specifically distinct, while there seems to be no sufficient reason at present for supposing that they are divisible into sub-species or definite races. The whaling industry of the far south is concerned mainly with three species, which are substantially identical with those known by the same names in northern waters, and collectively constitute an overwhelming majority of the whales captured. These are:—

(i) Humpback (*Megaptera nodosa*);
(ii) Fin whale (*Balænoptera physalus*);
(iii) Blue whale (*Balænoptera musculus*).

It may be observed that the fin whale is often referred to, in zoological literature, as *Balænoptera musculus;* while the blue whale is also known as Sibbald's rorqual or *Balænoptera sibbaldii.*

32. The right whale (*Balæna glacialis* or *B. australis*) and the sperm whale (*Physeter catodon* or *P. macrocephalus*) occur in much smaller numbers; but, in consequence of the high value of their products, they are eagerly hunted when an occasion offers itself. The sei whale, or Rudolphi's rorqual (*Balænoptera borealis*) was captured in moderate numbers at South Georgia in 1913-14 and 1917-18, but it is not of much practical importance farther south than the Falkland Islands. The smaller whales have not at presnt received much attention from the whalers, but of those which reach a length of from 25 to 35 feet, the lesser rorqual (*Balænoptera*

acutorostrata or *B. rostrata*) and the killer or grampus (*Orcinus orca* or *Orca gladiator*) are known to be found in considerable numbers in Antarctic waters; while the pilot whale, blackfish or caa'ing whale (*Globicephala melæna*) and the bottle-nosed whale (*Hyperoodon rostratus*) have occasionally appeared in the whalers' records. Other cetacea known to occur in southern waters need not be referred to.

33. The three principal species mentioned above have almost invariably constituted more than ninety-five per cent of the total catch. The relative importance of each kind may be illustrated by comparing the returns for the principal whaling season (1st October-31st March) at South Georgia in the eight years 1910-11 to 1917-18. The percentages of the total number of the three species are as follow :—

	1910-11.	1911-12.	1912-13.	1913-14.	1914-15.	1915-16.	1916-17.	1917-18.
Humpback	96·8	90·9	53·8	18·6	15·6	22·9	9·3	2·5
Fin whale	1·8	5·3	41·2	55·7	36·5	33·6	37·4	29·3
Blue whale	1·4	3·7	5·1	25·6	47·8	43·5	53·3	68·2
Actual total (of the three species)	5,472	5,607	4,187	2,542	4,043	5,510	3,600	2,664

34. These figures show that in the earlier years at South Georgia the humpback was the species principally hunted, while at the present time the catch of this species is small; that the fin whale next rose to importance as the catch of humpbacks declined, and that the blue whale has now become the principal object of the whalers' pursuit. This sequence corresponds with the order of size of the three species, the humpback seldom exceeding 50 feet in length, the fin whale rarely exceeding 85 feet, while the blue whale is occasionally recorded as reaching more than 100 feet in length.

35. The returns for the South Shetlands are less complete, but in the last three years (1915-16—1917-18) the humpback has formed a very unimportant constituent (1 to 6·5 per cent.) of the catch, which has consisted almost entirely of fin whales and blue whales, in varying proportions; the highest percentages being 68·9 for the blue whale in 1916-17 and 55·3 for the fin whale in 1917-18.

(*d*) *Breeding and Migrations of Whales.*

36. These two subjects appear to be closely related to one another, since some of the larger movements undertaken by whales are probably due to the fact that the localities preferred for breeding purposes are not identical with those where the richest supplies of food are found. The conditions which obtain during the summer in the neighbourhood of the Poles are known to be favourable for the development of enormous numbers of the pelagic crustacea on which the whalebone whales principally subsist. The waters of the Dependencies of the Falkland Islands are accordingly frequented by large numbers of these animals at the time when their food is abundant. The majority of them move away from the whaling grounds during the autumn, though a few remain all through the winter. The general course followed in migrating is best known in the case of the humpback, though the precise route taken by individuals leaving South Georgia or the South Shetlands is uncertain. It is known, however, that at about the time when most of the humpbacks disappear from Antarctic regions large schools have been observed off the coasts of South Africa, South America, Australia, and New Zealand. It can hardly be doubted that the individuals which have been feeding in sub-Antarctic waters during the summer travel in general in a northerly direction after the end of that period. The clearest evidence as to this migration is derived from the reports of observers on the African coasts, particularly on the western side of that continent, where large numbers of humpbacks have been found, at this season, as far north as the Equator, or even beyond it. It is definitely asserted that these whales pair and bring forth their young in the warmer waters, and that they subsequently return southwards, at a time of year which corresponds with their reappearance in the next spring on the whaling grounds of the Dependencies.

37. The migrations of the fin whale and of the blue whale are less fully understood. Observations indicate that in the northern hemisphere these two species move more or less towards the Pole in the spring, and more or less away from it in the autumn. The statistical examination of the records of fœtuses of both northern and southern whales, whether humpbacks, fin whales, or blue whales, gives some evidence that, in each species, there is a particular season of the year when pairing occurs with the greatest frequency, and that this lies outside the principal whaling season, which corresponds approximately with the three months on either side of midsummer. It may thus be inferred that, in all three species, the principal pairing season occurs at a time of year when the animals are not common on the whaling grounds of the far south, and accordingly that evidence of it is to be looked for in latitudes nearer the Equator. The statistics further point to the conclusion that parturition and pairing occur principally in months which are not very far apart. It seems probable that the humpback migrates farther north for these purposes than the other two species; and the high proportion of small humpback fœtuses which are obtained in the earlier months of the principal whaling season indicates that this species pairs later in the year than the fin whale and the blue whale.

38. There is at present hardly anything to show to what extent circumpolar migrations occur.

39. A small amount of direct evidence with regard to the migration of individual whales has been obtained by the recovery of lost harpoons in captured specimens, and it is clearly of importance to record carefully all cases of such recovery, even though it may not be possible eventually to ascertain the exact date and locality of the loss of the harpoon.

40. The adoption of a method of marking whales, probably by the use of a small projectile which could afterwards be recovered when the whale is finally captured, appears to us the most practical means of obtaining direct and conclusive evidence with regard to many important facts that need determination. Some of the migrations undertaken by individual whales could thus be definitely established, while if it were possible to mark a number of calves important information could be obtained with regard to the rate of growth and the age at which sexual maturity is reached. It is not too much to hope, moreover, that evidence might in due course be obtained as to the longevity of whales, a subject about which nothing definite is at present known. It is in the highest degree desirable that further experiments should be undertaken at an early date, in order to ascertain whether this method can be successfully employed. We suggest the construction of a projectile in the shape of a cartridge or harpoon consisting of two parts, a body which would either be detachable or be composed of some material which would rapidly disintegrate in the water, and a head in the form of a small barbed spike, attached to a numbered disc of bone, celluloid, or other suitable material. If fired with a suitable degree of force, the spike should remain embedded in the blubber, the disc remaining at the surface, where it would readily be observed, and the body of the projectile disappearing in the water. A careful record would, of course, be kept of the place, date, and other circumstances in which each such projectile was fired. A reward should be offered for every disc recovered.

(*e*) *Whale Food.*

41. Since it may be assumed that the whales visit the waters of the Dependencies in order to profit by the rich stores of food there present, the investigation of the food itself is of fundamental importance. It is generally believed that crustacea (mostly Euphausiidæ) constitute the greater part of this food, but the question should be definitely settled by the examination of stomach-contents and of the plankton* itself. The predominance of certain species in samples of whale-food should be noted, and it should be ascertained whether the whales of different species show a preference for particular kinds of plankton. The distribution and quantity of the whale-food need investigation, with regard to its occurrence in the Antarctic seas and on the whaling grounds in particular, the seasonal variations in its quantity, and the depth below the surface at which it

* Plankton is a term indicating the entire assemblage of floating organisms, whether of animal or of vegetable nature, whose major movements are those of the water in which they float.

is found at different seasons and at different hours of the day. The quantitative estimation of the plankton may well prove to be of more importance than detailed records of every species found in each sample of plankton. The subject is, however, one of vast dimensions, and some remarks directed to the restriction of plankton research within practicable and immediately valuable limits will be found in Appendix XVI.

42. The determination of the principal constituents of the plankton cannot, however, be neglected. Assuming that the main mass of the whale-food consists of crustacea, it has still to be ascertained what is the food of these organisms. It cannot be doubted that the *ultimate* food of the plankton-animals, including the whales themselves, consists of diatoms and other chlorophyll-containing vegetable organisms. Since these are presumably present in samples of water in which the "kril" abounds, it would be of interest to ascertain how far they are themselves whale-food, or whether the straining arrangements of the baleen-plates permit nearly all the microscopic organisms to escape and only retain the larger constituents of the plankton.

43. The prevalence of a rich supply of plankton depends on a proper combination of the factors of light, temperature, and chemical constitution of the water. Recommendations as to the investigations required in this connexion will be found in paragraphs 127 to 130.

44. Since the humpback and the fin whale are known to be largely fish-eaters in northern latitudes, it is desirable to know whether fishes form an important part of the diet of southern whales at any period of the year. There is some evidence that this is the case on the South African coast.

45. The sperm whale, which occurs, however, in very restricted numbers, would require some special investigation; and it should be ascertained whether it feeds during its visits to the far south, and, if so, what is the nature of its food.

(f) Researches required to supplement existing knowledge.

46. Although much is to be learnt from a direct study of the whales themselves, the solution of the many problems which require elucidation can only be obtained by means of investigations conceived on broad lines. The study of the statistical returns of the whaling companies has already yielded interesting results, and every effort should be made to secure a continuation of those returns which are at present made, and to obtain them from every locality in which whaling is carried on and from which none have yet been received. Information can be obtained in this way with regard to every individual whale captured, its species, sex, and total length, the date of its capture, and, in the case of pregnant females, the length of the fœtus. It is of special importance that a careful record should be made of the approximate latitude and longitude of the place of capture in each case.

47. It has been pointed out by Lord Rothschild (Appendix IX.) that the first evidence of the approaching extermination of a species is generally given by a diminution in size of the adult individuals recorded. The statistics should accordingly be carefully scrutinized from this point of view.

48. The dates of capture naturally give important information with regard to the seasonal occurrence of each species at the locality in question; and if records are made at distant localities they may throw considerable light on the migrations of whales.

49. The study of the fœtal lengths helps to decide the important questions of the length of the period of gestation, the rate of growth of the fœtus, and the approximate dates of impregnation and parturition.

50. Records of females accompanied by calves are more difficult to obtain, as the hunting of these females is prohibited by Ordinances already in force. If such females are captured, the whalers are not likely to record the presence of the calves, as they would thereby show that they had committed an illegal act. They might be encouraged, however, to make returns of females observed with calves, even though they were not captured, and to estimate as nearly as possible the length of the calves.

51. The record of the sexes might prove to be of considerable practical importance as throwing light on the question to what extent whales travel in schools of the same sex.

52. In addition to the information obtained from the statistics, a direct study of the whales by competent zoologists is of urgent importance. Evidence with regard to the species is specially required, and it should be ascertained whether the

whales which frequent the waters of the Dependencies are identical with those found off other coasts in the southern hemisphere and with those of the northern hemisphere. The question whether distinct sub-species or local races can be recognized also requires elucidation. The solution of these questions will involve the collection of a large amount of material, to be brought home for comparison with specimens in museums.

53. Much valuable study can be carried out at the whaling stations, where the specific characters of the whales can be investigated and the accuracy of the whalers' statistics can be checked. Among the problems which can thus be studied with advantage, those relating to reproduction will probably be found specially important. The length at which whales of each species become sexually mature can be investigated by means of an examination of the reproductive organs in both sexes. In the case of the females a careful examination of the ovaries should result in the acquisition of evidence with regard to the sexual cycle and the seasons at which ovulation, or the discharge of the ovum into the oviduct, takes place. It may well be found that the best results on this subject will be obtainable at the whaling stations on the African coasts, or at any rate at some locality farther north than South Georgia. It is certain that many of the fœtuses and a large proportion of the small ones are overlooked by the whalers; and examination by an experienced zoologist should result in the discovery of many which would otherwise have been missed, and particularly of the smaller fœtuses. The recording of these small fœtuses is specially important, as without them it cannot be ascertained what proportion of the females are pregnant; and this has considerable bearing on the question whether pregnancy takes place every year in breeding females. This inquiry should further assist in determining the breeding period, since the dates of impregnation and ovulation could be determined approximately by the discovery of embryos in their earliest stages of development, and by the evidence afforded by the condition of the ovaries. The finding of young embryos would no doubt be attended by special difficulties, in view of the enormous mass of the whales. The condition of the mammary glands would naturally be recorded, and evidence of lactation in pregnant females would be specially instructive. Examination of the stomach-contents would throw light on the nature of the food, while records of the thickness of the blubber, at different seasons and in different localities, would give some indication of the extent to which whales profit by their sojourn on the feeding grounds, and would show how far their general condition is correlated with reproductive phenomena.

54. Observations are further required on the living whales, their habits, their mode of feeding, the depth to which they dive, and the length of the periods of submersion, their association in pairs or schools, whether of individuals of the same sex and similar size, or otherwise, and on other questions. It would be particularly important to visit some of the breeding-grounds, to obtain direct observations on pairing and the appearance of young calves, with the object of discovering the dates when impregnation and parturition occur. Some evidence as to the direction of migration might be obtained by a vessel which placed itself in the migration routes. It would be desirable to ascertain to what extent whales feed while undertaking their principal migrations.

55. Some of the larger whales are known to be subject to attacks by killer whales (*Orcinus* or *Orca*), and to show symptoms of great terror at the approach of these animals. As the killer is abundant in Antarctic seas, it should receive some attention, with the view of ascertaining whether the larger whales are frightened away from their feeding grounds by the arrival of a school of these formidable cetacea. Even though adult whalebone whales may be able to avoid the attacks of the killers, it is probable that their calves are more subject to attack; and it is not impossible that some destruction of the killers (which would yield oil and other products) might be desirable in the interests of the larger whales.

56. It is obvious that these inquiries cannot be made satisfactorily and completely by investigations limited to the whaling grounds. The vessels of the expedition will probably have to spend part of their time at considerable distances from the Dependencies. The importance of simultaneous observations on the whales and on their food by two vessels operating at a distance from one another may be emphasized. It is further urgently desirable to visit the warmer regions frequented by whales at times when these animals are absent from the whaling grounds of the Dependencies.

Part of the work should be to examine and report on the methods adopted for hunting the whales; and this might be accomplished by means of trips made in whale-catchers. The observers should also familiarize themselves with the work of the shore stations and floating factories, with the view of making suggestions as to means of promoting economy in the utilization of the carcasses of the whales.

(g) Danger of the Depletion of the Stock of Whales.

57. The prevention of the extermination of the species of whales hunted in the Dependencies is undoubtedly one of the most important objects to be borne in mind. It is also well known that such operations may result in the disappearance of the whales from the area worked and the complete destruction of the local industry. Moreover, whaling in the Dependencies is only profitable when whales are plentiful, and a depletion of the stock falling far short of extermination may greatly injure the industry. The history of whaling operations in other localities shows conclusively that these dangers are not imaginary, and it should be one of the principal objects of the proposed expedition to obtain evidence bearing on the question whether whaling is being conducted on too extensive a scale, and to provide the information on which legislation can be based in order to regulate the industry satisfactorily. In this connexion it will be of great importance to test the theory which has been advanced by Dr. Hjort, Captain C. A. Larsen, and other Norwegian experts, that the Antarctic circumpolar waters constitute a vast reservoir of whales, and that losses in the Dependencies on the present scale of pursuit are naturally replaced from this source. It is necessary also to determine how far the statistics are affected by annual fluctuations due to a variety of natural causes, as apart from the whaling operations. This aspect of the question is discussed in Appendix XVI.

58. The serious diminution which has occurred in the number of humpbacks frequenting the southern whaling grounds is noticed in Appendix VIII. That this is regarded with apprehension by the local authorities appears from the fact that the Magistrate at South Georgia issued orders that humpbacks were not to be hunted within his jurisdiction during the whaling season of 1918-19. Although the fin whale and the blue whale give no immediate cause for anxiety, the statistics referring to these species will need careful watching; and it may prove necessary, in the interests of the whaling companies as much as of the whales themselves, to take measures for preventing an undue depletion of the stock of whales of every species hunted. The local manager of one of the whaling companies in South Georgia has recently informed the Governor of the Falkland Islands that it is the general opinion of the managers of the several stations in the Dependency that the period from the 15th May to the 30th September in each year should by regulation be made a close season.

(h) Future Control of the Whaling Industry.

59. The existing system of control is described in paragraphs 26 to 30. Pending the researches now in contemplation, we consider it premature to make detailed recommendations as to policy, but we desire to record our view that the grant of whaling rights for a long term of years is inadvisable, since it tends to fetter the discretion of the Government in imposing such restrictions as may, from time to time, be shown to be necessary. The conditions under which whaling is carried on from shore stations may render it impracticable, for commercial reasons, to make any renewal of such rights merely from year to year, as is actually done in the case of licences for floating factories and additional whale-catchers; but we are of opinion that, as the existing leases expire, careful consideration should be given to the question of limiting any renewals to the shortest possible period.

60. The system of issuing annual licences, with the accompanying restriction of the number of whale-catchers that may be used, seems to be a sound one, since the number of whales caught must necessarily have some relation to the number of vessels engaged in hunting them. The actual number of whale-catchers which should be licensed in a given locality is, of course, open to question.

61. It appears to us that the enforcement of the utmost economy in the utilization of the whale-products is of special importance. Evidence has been obtained that the economy effected is to some extent in inverse proportion to the number of whales captured. This conclusion may be reached by a study of the returns of the average number of barrels of oil per whale obtained in different seasons. In some of the years in which whales have been specially plentiful the average has

been conspicuously lower than in seasons when these animals have been scarce. It has been definitely admitted in some of these cases that whales have been brought in to the shore stations in such numbers that there has not been time to utilize the carcasses completely. Under such conditions the whalers naturally work up the most productive parts of the animals, and reject those from which a smaller proportion of oil can be obtained. In the years of scarcity it has been pointed out that every particle of whale-matter has been used. It should be noticed that in estimating the meaning of the averages recorded, account must be taken of the species of whales captured. It is obvious that a higher average number of barrels will be recorded from a catch consisting principally of large blue whales than from one which is composed mainly of small humpbacks.

62. It is not surprising that floating factories, which are exposed to all the vicissitudes of the weather in stormy seas, are far less efficient in working up all the products of the whales than the shore stations; and it has been found impossible, in practice, to insist on the complete utilization of the carcasses by these vessels. It is accordingly desirable to permit the use of the floating factories no more than is absolutely necessary. It is understood that this is in substance the existing policy of the Colonial Government.

63. The prevention of unnecessary waste is eminently desirable, since an uneconomical use of the material may involve the slaughter of three whales where two would have sufficed to obtain the same results. Every effort should accordingly be made to enforce the existing Regulations and to prevent the capture of whales in excess of the number which can be completely utilized.

(i) Introduction of British Personnel into the Whaling Industry.

64. In the days of the Greenland and Spitsbergen whaling industry Great Britain possessed a valuable national asset in the form of the numerous whaling population, hardy and highly skilled. Whaling vessels were fitted out from more than a dozen different ports, both English and Scotch, of which Hull was the chief. The numbers and grades of the boats' crews, flensers, and makers-off,* and the experience required before an individual could be admitted to a particular grade, were as minutely regulated by law as the service qualifying for master or mate is now.

65. Whaling was encouraged by the grant of bounties, very large in proportion to the revenue of Great Britain in those days. The industry was in close touch with the science of the time. One of the captains, W. Scoresby, Junior, became a Fellow of the Royal Society, and published in 1820 an admirable treatise dealing both with practical whaling and with the scientific study of the Arctic regions.

66. With the practical extermination of the Right or Greenland whale this whaling population and its highly qualified leaders disappeared, and cannot easily be replaced. "Right" whaling from Dundee long lingered, and from 1893 to 1911 the number of vessels employed averaged seven or eight. In 1912 it was reduced to a single ship.

67. Britain has never possessed any considerable population skilled in the pursuit of fin whales, for which the use of the bomb harpoon is necessary. A few Shetlanders have been employed in fin whaling, but they do not remain in the industry. The harpoon gun was brought to a practical stage by the Norwegian Svend Foyn, and up to the present practically all the skilled whalers have been Norwegians, both those who form crews of the whale-catchers and those who conduct the flensing and boiling at the factories. Most of them can speak a little English, but the difference of language is some hindrance to their mingling freely with the British, and a difference in diet is a more serious obstacle. Also, British seamen will not work well under the control of foreigners. Moreover, to man a whale-catcher with a British crew would involve an initial financial loss, which no company could be expected to incur. British gunners are second to none, but time is necessary to learn the use of the harpoon gun, and much more is needed to acquire local experience and that knowledge of the habits of the quarry which is an essential element in all hunting. The hardships of a whaler's life are considerable, and the Company has to take the risk that the crew may refuse to re-engage; this has actually happened with the Shetlanders already referred to.

* The operation of "making-off," which is now obsolete, consisted in freeing the blubber from muscle and skin, cutting it into small pieces, and packing it in casks for transport to England, where it was boiled down for oil.

68. It has been suggested that the British whaling crews could be trained in the waters of the United Kingdom, working from the Shetlands or from Ireland. We consider that this suggestion should be recommended to the attention of the proper authorities, but, in any case, few men could be employed in home waters, and it may be anticipated that only a small proportion of these men would be willing to work in the Dependencies of the Falkland Islands.

69. It is necessary to seek other means of overcoming the difficulties already mentioned, and the question of offering some special concession to a company operating in the Dependencies which is willing to grapple with them should be considered. This concession might take the form of an extra whale-catcher allowed upon the condition that its crew should be entirely British with the exception of a Norwegian instructor. To obtain gunnery practice for the crew it would probably be necessary to stipulate that the instructor should not be permitted to fire a gun at a whale. After some years the retention of the extra whale-catcher might be made conditional upon the provision of a British crew for one of the firm's other whale-catchers. In this way British crews and gunners might gradually be trained. If any additional whaling facilities are granted, another opportunity would be presented to provide for the entry of British subjects into the industry.

70. We recommend that this experiment should be tried, but it would be rash to assume that it will succeed. The British sailor has a large choice of seafaring occupations, and in whaling he would have to meet the competition of hardy and frugal men with long whaling experience.

71. There is not the same difficulty in introducing British labour into the floating factories and shore stations; and this should be definitely encouraged. Flensing and boiling offer considerable openings for labour, at first unskilled. Messrs. Salvesen are already endeavouring to man their floating factory "Neko" entirely by British labour, and they hope that it will be possible to achieve this result in the course of the next few years (see Appendix X.). It has been suggested that the employment of a proportion of British subjects should be enforced by regulation, but we do not recommend this course, since it seems to us that such regulations could not well be applied to the foreign floating factories and shore stations.

72. The grant of bounties in respect of the employment of British subjects would be possible, but it appears invidious to promote this object by means of local taxation, mainly paid by Norwegian companies, and if any such bounties are offered it appears desirable that the funds should be provided by the Imperial Government.

(*j*) *Whale Oil and Other Products of Whaling.*

73. Information relating to the products of the whaling industry and their commercial uses will be found in Appendices V., VI., and VII. We shall give here only a brief summary.

74. By far the most important product is the oil, and in peace time its principal use is for soap-making, with glycerine as a by-product. During the War this position was temporarily reversed owing to the demand for glycerine for the manufacture of explosives.

Whale oil is what is known as a soft oil, and is useless for the purpose of making hard soap until it is hydrogenated. The result of hydrogenation is a hard fat, white, odourless, and tasteless, which is a substitute for tallow. The best quality can be used for margarine, but at present manufacturers in the United Kingdom prefer other oils.

Grades 0, 1, and 2 of whale oil are suitable for soap-making, and grade 3 can be used for this purpose with some difficulty. The lower grades are chiefly employed for the manufacture of lubricating greases.

75. The treatment of whale oil evidently presents a number of chemical problems. We understand that these problems are being carefully studied in the United Kingdom by the companies interested, and it is, of course, out of the question that research work of this character should be undertaken to any great extent on board the proposed research ships. We recommend, however, that the members of the scientific staff of the ships who are suitably qualified should get into touch with the chemical staff of the manufacturers in order to ascertain whether there are any problems which require to be studied at the whaling factories in the Dependencies.

76. The demand for whale oil is practically unlimited, and prices are at present more than double those of 1914. Before the War the industry of hydrogenation was carried on mainly in Norway, the Netherlands, and Germany, but plant is now in operation in the United Kingdom on a scale adequate to deal with all the whale oil which is likely to arrive.

77. Representations have been made to us by Mr. Kingdon (see Appendix VII.) that it is absolutely necessary for the Government to take steps to secure that ample supplies of whale oil are brought to this country. In peace time it appears that the only practicable means of promoting this object would be the imposition of differential export duties in the Dependencies. We consider that this matter should be dealt with as one of general policy regarding Empire products of national importance and military value. But, in any action which may be contemplated as a matter of general policy, it should be remembered that the hydrogenating and soap-making industries are so combined that in existing circumstances there is practically but one buyer of whale oil in the United Kingdom. Accordingly, it is only at the expense of the producing firms that restrictions on the export of whale oil to other markets could be made effectual.

78. Other products of the whaling industry, such as sperm oil, guano, bone meal, etc., are dealt with in Appendix VI. It will be seen from Appendix XI. that an attempt to utilize whale guts proved unsuccessful. There may be other particular parts of whales which are worth study with a view to finding special uses for them. The treatment of the inferior whalebone known as "finners" has hitherto been conducted chiefly at Paris. There may be scope for British enterprise to undertake this treatment in the United Kingdom.

(*k*) *Whale Meat.*

79. It is clear that the fresh flesh of many species of cetaceans affords good and highly nutritive meat, but on many other points the information which we have been able to obtain is obscure, and in some cases conflicting.

80. Fresh whale meat is said to resemble beef. Opinions differ as to its taste, but it appears to be at least moderately good. Although Captain Larsen and Captain Sörlle state that it possesses a characteristic flavour of which it is impossible to get rid, we have been informed by others that they have not been conscious of this disadvantage, and have found the meat to be excellent. It forms a considerable part of the food of the whalers in the Dependencies.

81. Captain Larsen and Captain Sörlle state that it is improbable that whale meat by itself hermetically preserved would be useful for human consumption, as it is too dry and stringy, but that mixed with pork fat it could be made into sausages and meat cakes. Mr. R. C. Andrews, in his book "Whale Hunting with Gun and Camera," states that whale meat "canned in the Japanese fashion, is vastly superior to much of the beef and other tinned foods now on sale in our markets," and that in New Zealand a great deal of whale meat is canned.

82. Captain Larsen and Captain Sörlle also state that whale meat must be used within twenty hours of the killing of the whale, and that accordingly a central canning factory in South Georgia would not be practicable, but that a separate factory would be required at each whaling station. It has, however, been suggested that twenty hours is too short a time for the onset of putrefaction of the flesh in a cold climate, and that the development of a characteristic flavour may be due to some slight chemical change which could perhaps be prevented from taking place. Treatment with soda, or parboiling the flesh, is said to be advantageous in counteracting the change in flavour.

83. We have received no reliable information as to the relative quality of the flesh of different parts of the same whale, or of the different species of whales, but there is some indication that the meat of the largest whales is inferior to that of small ones.

84. Many of these points need further inquiry, and we would suggest that some of them could best be investigated, at least in the first instance, at the whaling stations in the northern hemisphere, such as the Shetland Islands or Ireland, if whaling from Ireland is resumed. The doubts as to flavour could thus be set at rest, and observations could be made as to the relative quality of different species and parts of whales. It might also be possible to send samples to London in cold storage, in sufficient quantity to enable the opinion of the meat trade and the public

to be ascertained. Samples of canned whale meat might be obtained from the United States, New Zealand, Japan, Norway, and, perhaps (through Messrs. Irvin), South Africa, with particulars as to species, process employed, and added substances such as pork fat.

85. We think that a moderate expenditure from the funds of the Dependencies upon these inquiries would be justified by the consideration that if success were achieved the value of the products of the whaling industry would be greatly increased. The subject is closely akin to those which are being studied by the Food Investigation Board of the Department of Scientific and Industrial Research and the Canning Committee of the Board of Agriculture and Fisheries, and we recommend that these bodies should be asked to arrange for the conduct of the inquiries, in consultation with the British Museum (Natural History). As dolphins and porpoises are known to be very good eating, it may be found advisable to investigate their treatment for food.

If the course of the investigations in the British Isles is sufficiently encouraging they can be verified in the Dependencies.

86. The question to be kept in view is that of the possibility of establishing in the Dependencies an export trade in whale meat, either canned or preserved, or fresh in cold storage. The latter trade is unlikely to be commercially practicable unless it be on a sufficient scale to supply a steamer with a full cargo. It is conceivable that in the future such a trade may be combined with one in frozen mutton from the Falkland Islands, but at present mutton is exported only when canned.

Part III.—The Sealing Industry.

(*a*) *Species of Seals.*

87. The southern seals comprise the following species: the fur seal, the sea-lion, the sea-elephant, and the hair seals known as the sea-leopard, the crab-eater, Weddell's and Ross's seals. Information as to the distribution of these species in the Dependencies will be found in Appendix XIV. The fur seal, which was at one time abundant, was practically exterminated at the South Shetlands in two seasons early in the nineteenth century; and the species is believed to have disappeared from South Georgia about 1874. It is impossible to condemn in too severe terms the indiscriminate slaughter to which these animals were subjected. The result was, as Dr. Bruce described it to us, a most important economic disaster, and it should never be forgotten as a warning against the uncontrolled exploitation of animal life for commercial purposes.

88. So far as is known no fur seals are now to be found in the Dependencies, though a single specimen, apparently a casual visitor, was observed at South Georgia in 1915 and unfortunately killed by mistake. The skin has been presented to the Natural History Museum. Captain C. A. Larsen mentions (see Appendix XI.) instances in which fur seals are reported to have been observed in recent years, but these have not been confirmed from any other source. From the annual reports of the Magistrate on the sealing season it appears that, with the single exception of the specimen already referred to, no trace of the fur seal has been discovered at South Georgia since the year 1910, when the first sealing licence was issued. Further inquiry would, however, be necessary to establish definitely that the species does not exist in the Dependency. The other species of seal normally found at South Georgia are the sea-elephant, Weddell's seal, and the sea-leopard.

89. Little information is on record as to seal life in the South Shetlands, and a thorough investigation of the seals of this Dependency is very desirable. It is, perhaps, not impossible that a complete survey of the seal life of the islands might reveal remnants of the once abundant fur seal; but the whaling captains interviewed by Dr. Bruce in September, 1918 (Appendix III.), reported that no fur seal were known either in the South Shetlands or in South Georgia. They also reported a few sea-elephants in the former Dependency, and plenty of Weddell's seals and sea-leopards.

There is no record of the presence of fur seals at the South Orkney or South Sandwich Islands in recent times: but other species of seals are represented at these groups.

(*b*) *Description of the Industry.*

90. Of the southern seals only the fur seal and the sea-elephant have any economic interest. The fur seal, as its name implies, is of commercial importance because of the value of its skin; while the sea-elephant is pursued entirely

for the oil which it yields, the skins not being utilized. The re-establishment of the fur seal in the Dependencies would, if feasible, add materially to the economic yield of these regions. The pursuit of the sea-elephant, which abounds in South Georgia in particular, is regulated by law, which covers all kinds of seals. Both these species are dealt with more fully below. Small numbers of Weddell's seals and sea-leopards are taken at South Georgia, but neither species appears to be in any danger of extermination, since the animals are of little commercial value, as the yield of oil is small and the skins, after preparation, do not realize sufficient to cover expenses. As Weddell's seals are scarce at South Georgia it would be well to prohibit their capture altogether in that Dependency. The sea-leopard, on the other hand, is a ferocious pest, which preys on penguins as well as fish, and any diminution in its numbers may, perhaps, be viewed with equanimity.

91. Appendix XIV. contains an account of the sealing industry, together with particulars of the legislation in force and the measures taken locally with a view to the preservation of the various species. The law prohibits sealing without a licence and provides for the declaration of seal reserves. The most recent licences restrict the number of seals to be taken; prohibit the killing of young seals; require that the killing of females should be avoided as far as possible: and provide for a close season. Dr. Bruce has furnished us with much interesting and valuable information as to the results of sealing operations in the Dependencies in the early part of the nineteenth century (see Appendices I. and II.).

92. At the present time South Georgia is the only Dependency in which sealing operations are carried on; licences to take seals having been issued since the year 1910. The coast of South Georgia is divided, for sealing purposes, into four divisions, which are shown in the map of the Island (*see frontispiece*). Not more than three divisions have been worked in any one year. The division kept in reserve has usually been Division IV., but in 1918 was Division II.

93. In considering the question of seal life in the Dependencies we have given special consideration to the following questions: (*a*) the possibility of re-establishing the fur seal, and (*b*) the preservation of the sea-elephant.

(*c.*) *Re-establishment of the Fur Seal.*

94. This question has already engaged the attention of the Colonial Office. In view of the economic value of the fur seal the possibility of re-establishing the species in its natural habitat in the Dependencies is one that deserves serious consideration; and the restocking of the breeding-grounds could be attempted by the introduction of specimens from existing "rookeries" elsewhere in the South Atlantic. In trying this experiment it would be desirable to select localities which are known on historical evidence to have formerly served as breeding-grounds. Such an experiment could most conveniently be made at South Georgia where, as the island is the seat of whaling industry carried on all the year round, the results could be most easily watched and protection afforded to the animals if the attempt proved successful. In that event a further effort might be made to restock the rookeries at the South Shetlands, where the fur seal formerly existed in enormous numbers.

95. The success of the experiment cannot be predicted with certainty, because it is an essential fact in the habits of these animals that they spend a considerable part of their lives in the open sea, and probably travel far from the breeding-grounds, which they only visit during certain months of the year. It also appears that the seals of different ages and sexes separate widely during their migrations and return to the rookeries at varying times. Even though a small colony could be introduced at a given place, consisting of a suitable number of breeding males and females, with younger specimens, it does not follow that the animals would revisit the same place in the next season. They might, on the contrary, return to the district from which they had been taken.

96. In spite of this doubt we recommend that the experiment should be made. Even if it should fail the loss would not be material whereas, should it succeed, the result would be a considerable accession to the economic resources of the Dependencies. The scientific system of control which has been adopted by the United States Government in the Pribylof Islands (Bering Sea has shown that, by suitable methods, fur seals can be farmed as successfully as ordinary domestic animals. These animals are polygamous, and in the North, at least, the young males, before they come to the breeding age, segregate themselves into separate herds on the islands visited by the fur seals for breeding purposes. It

is accordingly possible to limit the catch to a certain proportion of these "bachelors," and to do so without injury to the species as a whole. If fur seals could be re-established in the South similar methods might be expected to produce equally favourable results. It is of great importance to prohibit what is known as "pelagic sealing," by international agreement, if necessary, as well as to protect the animals while ashore. By "pelagic sealing" is meant the hunting of the animals while in the open sea, as distinguished from the operation of killing them on the breeding-grounds. The females give birth to their young almost immediately after landing, while they make frequent excursions out to sea for the purpose of feeding while they are nursing their young on shore. One of the evil results of pelagic sealing is to destroy numbers of pregnant females, or, by destroying nursing females, to involve the death of the young ashore. Another bad effect is that numbers of the animals killed are not recovered, and an entirely useless slaughter thus results. Pelagic sealing involves the destruction of animals of both sexes and of all ages, and it thus fails to take that toll of the species which can be taken with the least injury to its numbers.

(d) Preservation of the Elephant-seal or Sea-elephant.

97. In view of the instances which have occurred in the past of irreparable harm to animal life, due to indiscriminate and reckless slaughter, a not unnatural anxiety has been expressed to us as to the condition of the sea-elephants at South Georgia, where numbers of these animals are taken annually for commercial purposes. Whatever danger may have threatened in the past it is gratifying to be able to record that, as shewn in the summary of the annual reports of the Magistrate (Appendix XIV.), the sea-elephant has since rehabilitated itself and is now found in large numbers. In these circumstances the Government is fairly entitled to claim that the policy pursued since the passing of the Seal Fishery Ordinance in 1909 has successfully protected these animals. Under the existing law and regulations, and with the strict limitation of the number of licences issued, there seems no reason to be apprehensive of any immediate danger to the herds, although vigilance should not, of course, be relaxed. We are, therefore, of opinion that while present conditions continue the question of any change of policy may be deferred pending expert investigation of the rookeries.

98. There is, however, one point to which we desire to draw special attention. The account of the habits of the sea-elephant given in Appendix XV. indicates that the animal is polygamous and that, in general, its characteristics in this respect resemble those of the northern fur seal. This apparent resemblance in breeding habits suggests the possibility that the system of farming the fur seal at the Pribylof Islands, which is described in paragraph 96 above, might profitably be adapted to the case of the sea-elephant. There is, however, from the economic point of view, one important distinction between the species which should be noted in this connexion. This is the fact that, in the case of the fur seal, it is economically possible, while scientifically desirable, to confine the catch to young non-breeding males, whereas, in the case of the sea-elephant, the full grown males are of most value commercially on account of the quantity of oil which they contain. The matter is, however, one which must be left to expert consideration.

99. In concluding this section of our report we recommend that the special examination of the life history and habits of seals of the Dependencies should form part of the work of the biologists attached to the proposed expedition. Apart from the possibility of the re-establishment of the fur seal there will be important work for a biologist in observing the habits of the sea-elephant. It may, therefore, be desirable to employ, for a time at any rate, an additional biologist for this and similar purposes. Such an officer would work mainly on shore and his employment would not necessitate the provision of additional accommodation for him on one of the research vessels.

Part IV.—Fish, Penguins, and Other Animals.

(a) Fisheries.

100. In regard to fisheries (see Appendix XVII), it is natural to consider the Dependencies of the Falkland Islands in connexion with these islands themselves; and there are certain features which give rise to the expectation that the waters in the vicinity of the Falkland Islands are more suitable for an early development of the fisheries than are those of the Dependencies. Nevertheless, there are some

reasons for considering it probable that workable accumulations of marketable fish exist in the waters of the Dependencies, and a survey should certainly be made, mainly and first in the shoal waters about the island groups. It is important that in this work actual fishing gear of approximately commercial dimensions should be employed, managed by experienced fishermen.

101. The markets of South America are known to absorb large quantities of imported fish. The Argentine, in some respects the most convenient market for the Dependencies to enter, in 1914 took over nine thousand metric tons, with a value of more than £380,000, while Brazil imported between five and six times as much. War has produced a great shortage of fish with a corresponding rise of prices. Moreover, should the present meat shortage continue for some years, as is the general expectation, the demand for fish will continue large, even when transport has recovered. In the near future, therefore, supplies of fish should be exceptionally welcome. At present existing supplies for the more southern States bordering the Atlantic are furnished mainly by the distant waters of Europe, Norway being a large contributor. Newfoundland and Canada are very large exporters to Brazil, and their influence will no doubt extend farther south; but, as against Norway, in all cases, and against North America also for the Argentine, Uruguay, and Chile, the advantage of shorter transport through cooler waters lies with the Dependencies. Efforts are being made by at least one South American Government to develop the fisheries of their home waters.

102. It must be freely admitted that the infant industry would labour under certain difficulties. Fishery supplies would need to be imported. The steamers which now proceed to South Georgia with coal and stores and return with whale oil carry full cargoes outwards, but their existence would make it possible to send out trial consignments of supplies at less cost than if a special steamer had to be engaged. A permanent industry would need to employ additional vessels for the importation of its supplies, but the resources of these vessels for the export of the products of the industry would probably be augmented by occasional vacant space in the transport vessels of the whaling industry. Such space would only be suitable for cargo not liable to be tainted by whale oil. The islands are remote from ordinary trade routes, and consequently can expect no other opportunities for exportation. Remoteness of the origin of the usual sources of fishing supplies also would increase the cost of the fish to the exporter. Of the necessary material coal is probably the most important, and discoveries of coal within the Dependencies would thus greatly improve the prospects of fishery development. The whole advantage due to shortness of transport clearly could not be expected to accrue. It does not, however, follow that this advantage would be wiped out, nor that the disadvantages referred to could not be greatly mitigated by careful management and adaptation of the industry to the prevalent conditions, as, for instance, by the use of oil in place of coal in the vessels employed in the trade.

103. Supposing supplies of fish to be plentiful, the successful launching of the product of the industry on these markets would depend not only on efficient fishing and good methods on shore, but on the careful choice of a time for presenting the first consignments to the market; and, above all, care is essential that, from the start, these should be of really good quality. It is also of the greatest importance to determine the best methods of preserving, both by canning and refrigeration, since fish successfully treated by either of these processes would be given a superiority over the salted fish now predominating in the imports, and thus, judging by experience in the British Isles, would have the advantage in the markets. This question of preservation is already being dealt with by the Food Investigation Board.

104. The first and most important step, however, is obviously the location of marketable quantities of fish.

(*b*) *Penguins.*

105. The penguins, which form one of the most characteristic features of the fauna of the Antarctic, and have repeatedly proved a valuable food in times of emergency, are from their nesting habits and defencelessness peculiarly liable to attack wherever their "rookeries" are accessible. It is, therefore, a cause for satisfaction that they are the subject of protective regulation. An Ordinance (see Appendix XVIII.) passed in 1909 made it illegal to kill penguins without a licence

and protection is still in force. Permission has been given for a few birds to be taken for scientific purposes or for food.

106. As an article of food in a region in which but little variety is obtainable, penguins are not without importance. Dr. Bruce found the Adélie penguin (*Pygoscelis adeliae*), which is a common species in the South Shetlands, the most suitable for food, and he describes various ways of preparing their breasts for this purpose. This bird furnished the winter food of the twenty men forming the hut party of the Swedish Antarctic expedition. Several other species of penguins are known to occur in the South Shetlands or in other parts of the Dependencies; these birds or their eggs may form a considerable addition to the supplies of an expedition.

107. Quite apart from any considerations of sentiment or of science, it is desirable to keep in touch with the position as to the stock of penguins, in view of their food value. The number of licences which can be granted without depletion of stock, as well as the extent of the utilization of the penguins or their eggs which may safely be permitted, can only be determined by observation, and periodic examination of the known rookeries, with a view to estimating the numbers of birds present, is therefore desirable.

(*c*) *Acclimatization of Animals.*

108. Certain experiments which fall under this head have already been tried at South Georgia (see Appendix XVIII.)

Some success has already attended an attempt to introduce the reindeer, an animal of great economic importance in northern latitudes. The progress of this experiment should be watched with interest, and measures should be taken by which this animal may be afforded an opportunity of establishing itself.

Sheep have been introduced into South Georgia, but the results have not been encouraging as these animals cannot survive the winter unless specially protected. Their presence has, moreover, been said to result in the destruction of the native vegetation in places where they have been kept; and, unless it should be found that this apparent destruction is only temporary, the effect they produce on the vegetation would seem to be a serious obstacle to keeping them.

Rabbits introduced in 1872 did not survive.

Horses have also been introduced into South Georgia, and they appear to be more successful than sheep in resisting the rigors of the climate. A certain number of them are said to be running wild and to be capable of taking care of themselves.

109. An island like South Georgia, of limited extent, and characterized by the possession of a rigorous climate, cannot be expected to support a varied assortment of large animals. It seems probable that it would be better to give the reindeer a fair chance than to attempt to introduce other large mammals, which might compete with it for the limited store of natural vegetation. If it is thought advisable to make further experiments, some form of mountain sheep—perhaps the Alaska sheep—or domestic goats might be selected.

110. The introduction of smaller mammals should only be tried with great caution, in view of the undesirability of introducing any animal which would destroy the native fauna, and particularly the ground-nesting penguins. The importation of any carnivorous animal (such as foxes) other than seals is to be deprecated for this reason. The musquash, or musk rat, a rodent of North America, which produces fur of considerable value, has been suggested as a desirable colonist, which might establish itself. But the musquash, like many other rodents, varies its diet by taking animal food; and it may be anticipated that it would prove highly destructive to the penguins.

111. It may be noted that the brown rat, which was accidentally introduced, now occurs in enormous numbers on the shores, where it feeds partly on the remains of whales. It is possible that the rat may become a very serious problem, particularly should the catch of whales fall off to such an extent that it would have to devote more of its attention to other kinds of food. There are already indications that it may interfere seriously with birds which nest on the ground in positions where their eggs and young are easily open to attack. The eggs of penguins may prove to be a product of economic importance should it be found possible to collect a certain proportion of them without too much injury to the species. The brown rat has always been found to be an undesirable colonist, and the reduction of its

numbers, or its complete extermination, if that were possible, would probably be an unmixed advantage.

112. Some form of game bird might, perhaps, be introduced with advantage; and the European willow grouse is one that might be specially considered. Falkland geese (*Chloephaga magellanica*), introduced since 1900, appear to be thriving.

Part V.—Hydrography.

(*a*) *Survey* (*including Marine Casualties*).

113. Our knowledge of the hydrography of the Dependencies is exceedingly meagre, being dependent mainly on old reports, partial surveys by Antarctic expeditions, and a fairly numerous collection of sketch plans of harbours by various whaling captains, which are by no means valueless, but which, being totally unconnected with one another, are difficult to utilize.

114. As will be seen from Appendices III. and XIX. a new plan of the South Shetlands has been prepared by Dr. Bruce, but it is admittedly only a compilation from very conflicting material, and it is gathered that it has been subjected to much criticism from the Norwegian whaling captains.

115. The South Orkneys were partially examined by the "Scotia," but the whole area between the South Shetlands and South Orkneys is practically untouched.

116. Graham Land is perhaps in a somewhat better condition on account of the good work done by the Belgian expedition and the two expeditions under Dr. Charcot, in 1903-5 and 1908-10, in the known portions between 65° and 80° S., but north-eastward of Possession Island there is very little work that is at all reliable.

117. The South Sandwich group has never been examined, and the only information that we have upon these islands is derived from Bellingshausen (1820) and a few remarks from Captain C. A. Larsen. They are, however, apparently of little or no commercial importance.

118. South Georgia.—The importance of a complete survey of this island is greatly emphasized by Mr. T. E. Salvesen (Appendix X.) and Dr. Rudmose Brown (Appendix IV.), the former having asked for one as far back as 1912. Our information at present is derived mainly from a sketch map of a portion of the island by Mr. J. Innes Wilson, a former magistrate (which, however, is confined to the land surface), a few plans by the German expedition of 1882, and various sketch plans of harbours by men who had little or no surveying experience.

119. The marine casualties within the area do not at first sight appear to have been very numerous, but it must be remembered that, apart from the small whaling steamers, the number of vessels employed is small, although their value, including their cargoes, is very great.

(*b*) *Currents.*

120. Our knowledge of the currents within the area south of the main track of vessels round Cape Horn is also extremely limited. Observations are greatly wanted, and could be obtained in connexion with deep-sea soundings and other surveying operations. (See Appendices XIX., XX., and XXI.)

(*c*) *Tides and Tidal Streams.*

121. Very little has been done within the area concerned, and observations on both are needed. The rise and fall is known to be small, but, being within the area from which the great tidal wave originates, observations would be of the greatest value, and it is of special importance that, wherever possible, continuous observations should be secured by means of an automatic gauge. On the other hand, the streams must in many places be of considerable strength, and a knowledge of them would be of the greatest use to the mariner and biologist. (See Appendices XIX. and XX.)

(*d*) *Sea Temperatures.*

122. Of these, apart from surface temperatures, very few observations appear to have been taken, but they are very much wanted throughout the whole area in connexion with the study of the distribution of plankton (see Appendix XX.) They could be obtained in conjunction with deep-sea soundings.

(*e*) *Ice Conditions.*

123. There are a considerable number of disconnected ice reports, but it seems most desirable that there should be some more or less continuous observation of the

ice limits, at all events during the summer months. There can be no doubt that the limits of the ice barrier in the southern hemisphere must have a considerable effect on the meteorology of other parts of the world. (See Appendix XIX.)

(f) Deep-sea Soundings.

124. Except in the Weddell Sea exceedingly few soundings have been taken, and, in view of the fact that in 1916 a rock was reported about midway between South Georgia and the South Orkneys, it seems probable that such observations would be most valuable. Deep-sea soundings and observations on currents and sea temperatures could be carried on simultaneously, together with the collection of water samples for the determination of salinity, so that full use would be made of the time expended upon such work. (See Appendices I., II., and XIX.)

(g) Other Geodetic Observations.

125. We are advised that pendulum observations are not such as can be successfully undertaken as a side issue to other work.

(h) Chemical and Physical Observations.

126. In addition to frequent observations of currents by means of current meters, it is desirable that chemical and physical observations on the sea water should be made from the research vessels. As pointed out in paragraphs 41 to 45 above, and by Dr. G. H. Fowler in Appendix XX., it is of the greatest importance to determine the factors which govern the distribution of the food of the whales and their major movements in the ocean. Directly or indirectly, however, the food supply of whales must clearly consist of the plankton, whose movements are that of the water in which it floats, and whose abundance depends on the constitution and condition of that water, on temperature and on sunlight. In other regions it has been found possible, by the study of the sea water, to determine the seasonal movements of great masses of the sea, and to trace the source of various constituent bodies of water in the area, as well as the dependence of their movements on even distant oceanic conditions; and, in the analogous problems of the sea fisheries, information as to the movements and constitution of the water ascertained in this manner has proved of great service in the study of the conditions of abundance, or, again, the distribution, of important food fishes. (See Appendix XVI.).

127. The difference between the productivity of whaling at various seasons is very probably due in part to a change in the locus of congregation of the whales, or in the migration of the schools: difference of distribution in different years, at the same period of the year, is indeed frequently alleged by witnesses. It is clearly in the differences between the conditions in the waters of the Dependencies in various years that the causes of such fluctuations of abundance, as apart from any effect of the whaling operations, must be sought. Again, a point most important for the solution of the problems connected with the industry is the determination of the question whether the whales are distributed somewhat indiscriminately about the whole of the Antarctic Ocean, or are, on the other hand, confined for the most part to certain definite portions of it; and it would aid greatly in the solution of this question if the homogeneity of the waters of the Dependencies and those bordering this area could be established, or if, on the contrary, a definite system of distribution of various main water masses could be ascertained.

128. For the solution of such problems an understanding of the various strata of the ocean, their movements and relations, and the effect of these upon the organic life they bear, is indispensable. The field of work opened up, particularly when the area covered by the movements of whales is borne in mind, is accordingly immense; but with due selection of the lines of research, and a constant effort, as experience accumulates, to narrow them more effectually to those most immediately relevant, it is felt that progress will be practicable. The collection of samples and the chemical work necessary for the tracing out of the limits and movements of water masses fortunately possess the advantage of simplicity of execution at sea, and of rapid completion in the laboratory. The carrying out of a complete observation with current meters is a somewhat delicate operation, involving a stationary ship and careful manipulation of the instruments employed. Such experiments would, therefore, occupy a great deal of the time of the ship and staff, and would, moreover, frequently be impracticable in these regions on account of

the depth of the water and the heavy weather so often prevailing. Water samples, on the other hand, could be taken fairly easily, and even those below the surface would be more frequently obtainable than would satisfactory results from current meters. Total salinity can be determined rapidly in accordance with standard methods, and this determination can be carried out even after some time has elapsed from the collection of the sample.

129. It is, therefore, considered essential that samples should be collected by the ships in accordance with well constructed programmes, and, further, it is to be recommended that the collection of at least surface samples, and of sea temperatures, carried out at regular intervals of time, should form part of the routine working of the ships. In framing such plans for the work regard should be had to existing information as to the hydrography of the South Atlantic, of which an indication is given in Appendix XVI. The Appendix also draws attention to the desirability of testing gear for the collection of samples while under way, and to the need of utilizing to the full the results of other researches. In this connexion it is most important that arrangements should be made with steamship lines traversing the South Atlantic and South Pacific, for the collection of water samples and temperatures from the surface. Observations on a large scale have already been carried out over portions of the North Atlantic in this way, and the practicability of the procedure, which should be extended to whaling vessels wherever possible, is therefore established. Full use should also be made of the data amassed by the International Council for the Exploration of the Sea in regard to the North Atlantic, as well as of the standardization of apparatus and methods which has developed and been co-ordinated by the investigators co-operating in its labours.

130. From the above it would appear that a complete hydrographical survey of all these groups is necessary, both in the interest of the whaling industry and of the biological and other scientific inquiries that are desirable. Apart from those affecting the whaling industry, these inquiries are of considerable general importance, and accordingly the proposed hydrographic survey is of much more than merely local interest.

Part VI.—Meteorology and Magnetism.

(*a*) *Meteorology.*

131. In the inquiries relating to meteorology the questions before the Committee resolved themselves into one simple issue, whether the contributions towards this science which could be made by an expert meteorologist as a member of the proposed expedition were likely to prove of sufficient importance to warrant his being included in the limited staff for which accommodation could be provided on the research vessel or vessels. In this matter we have obtained valuable advice from the Director of the Meteorological Office, Sir Napier Shaw; while Mr. Mossman, whose meteorological work in Antarctic regions renders him particularly competent to speak on the subject, has placed copies of his memorandum on Southern Hemisphere Seasonal Correlations at the disposal of the Committee, and has favoured them with some notes, which are reproduced in Appendix XXIII. On the initiative of the Committee the Colonial Office also addressed the Governments of the Union of South Africa, of India, and of Egypt, and the Air Ministry, to ascertain how far they would be interested in any meteorological work that could be carried out by a member of the expedition.

132. A memorandum of the interview between the Committee and Sir Napier Shaw will be found in Appendix XXII., and it will be seen that he strongly advocates the employment of a trained meteorologist, provided with special equipment, as a member of the expedition. He has commented very favourably upon the interesting observations from which Mr Mossman deduces a close relation between the meteorological conditions of the Antarctic regions at certain seasons of the year and those which prevail in South Africa, Egypt, and India, and Mr. Mossman himself emphatically endorses the view that an expert meteorologist should accompany the expedition. The Air Ministry and the Governments of the Union of South Africa, India, and Egypt are also anxious that this opportunity of improving our knowledge of the meteorological conditions of this area should not be lost.

133. We accept the view which has been pressed thus strongly upon us, and recommend that a carefully selected, trained meteorologist should be detailed by the Imperial Government to accompany the expedition, and should be provided with full and properly tested equipment. Every facility should be given to him to take observations both at sea and on land, and to co-operate with the observers at the meteorological station maintained by the Government of the Argentine Republic on Laurie Island.

(*b*) *Magnetism.*

134. Magnetic observations for variation, dip, and horizontal force are very desirable in areas such as those of the Dependencies that are but rarely visited by observers, and as the survey will probably occupy a considerable period a unique opportunity will be afforded for obtaining the secular change of those elements.

We are advised that the following stations for magnetic observations would be desirable:—

South Georgia: Three stations, representing the north-western, north-eastern, and southern parts of the island.

South Shetlands: Two stations, north-east and south-west, respectively.

South Orkneys: Laurie Island—site of the Argentine Observatory.

Sandwich Islands: Two stations, representing north and south.

At least the officer in command of each ship should go through a course of magnetism at Kew Observatory if he has not previously done so. (See Appendix XXIV.)

Part VII.—Geology and Mineralogy.

135. An account of the geological work carried out in the Dependencies is given in the memorandum of the evidence of Dr. Evans and Mr. Green (Appendix XXV.), which shows that the geology of the area is extremely varied in formations, structure, and rock types, and that there is much work to be done on the scientific side which is of great interest. It is also possible that such work may lead to results of economic value, although, owing to physical conditions, the opening up and exploitation of mineral wealth in the Dependencies would be attended by serious difficulties. These, however, should not prove insuperable if valuable deposits are discovered. The discovery of fuel in any form would be of particular value to the whaling industry. Although the occurrence of coal is not impossible, the prospect is not promising, but if found it would probably be in sufficiently large quantities. At least one specimen of ore rich in copper has already been discovered, and an investigation of South Georgia, the South Orkneys, and the whole of the Graham Land region may not unreasonably be expected to disclose the existence of metalliferous deposits. It is also possible that the sulphur which occurs in the South Sandwich Islands may prove to be of economic value.

136. While we recognize that there is but small prospect of successful mining operations in the Dependencies on a commercial scale, we consider that such a development is not impossible, and this, combined with the scientific interest of the area, would amply justify a thorough examination of the geology of these regions. We concur in the view expressed to us that the mere collection of specimens for subsequent examination would not be a satisfactory method of investigation; and we accordingly recommend that a trained geologist with some experience of survey work in the field should be attached to the expedition for the purpose. At first researches should be limited to a general investigation on survey lines, with a view not only to prospecting for minerals, but also to the accumulation of data for the preparation of accurate geological maps. The question of borings and elaborate geological work should be left over for future consideration in the light of the results so obtained; but as the accommodation available on the research vessels is necessarily restricted, and the geological work is of less importance than biological and hydrographic researches, it is desirable that the geologist should be attached to the expedition for a limited period only in the first instance. If, after adequate time has been allowed for the proposed general survey, it should appear that the continued employment of a geologist is unlikely to have any valuable economic result, the opportunity should be taken of finding accommodation for a specialist in some other scientific field.

Part VIII.—Botany.

137. The question of the investigation of the vegetable organisms in the sea is dealt with in the section relating to hydrography (paragraphs 126 to 130). A short account of the plant life of South Georgia, together with a list of species collected during the visit of H.M.S. "Sappho" in 1906, will be found in Appendix XVIII. Owing to the climatic conditions the vegetation of the Dependencies is of the scantiest description, and cultivation appears to be impracticable, even at South Georgia. It is clear, therefore, that the Dependencies are of little, if any, economic importance from a botanical point of view; but it would seem desirable that the biologists of the expedition should devote some attention to the botany of the islands, particularly in relation to the question of the acclimatization of animals.

Part IX.—Research Vessels.

138. As the employment of a special vessel or vessels would obviously be necessary in order to carry out in the Dependencies scientific and economic researches of the nature contemplated, we thought it desirable at an early stage of our proceedings to remit to a Sub-Committee the question of the type of vessel and equipment required.

In view of his unique experience of these regions, Dr. Bruce was invited, and kindly consented, to serve on the Sub-Committee; and we are much indebted to him, not only for his invaluable advice as to the most suitable types of vessel, but also for furnishing a provisional list of the necessary technical equipment, which has formed the basis of the list given in Appendix XXVI. Dr. Bruce also provided a list of meteorological equipment suggested by Mr. R. C. Mossman, and we wish to take this opportunity of expressing our thanks to the latter gentleman for his assistance in this matter.

139. The report of the Sub-Committee is printed as Appendix XXVI., and the recommendations, in which we concur, may be briefly summarized as follows:—

Two vessels should be employed, one being approximately the size of H.M. surveying vessel "Endeavour" (about 700 tons net), and the other of similar size to the "Scotia" (215 tons net), the vessel of the Scottish National Antarctic Expedition. The vessels should work in intimate connexion with one another, the smaller being rather in the nature of a tender to the larger. Both vessels should be wooden three-masted topsail schooners, with steam power, and should be equipped with wireless installations. The smaller vessel should be fully protected for work in heavy ice; but, in the case of the larger, it would be sufficient to provide protection at the bows and stern only. In addition to the necessary cabin accommodation each vessel should be provided with two laboratories—the larger on the upper, and the smaller on the main, deck; a chart room, which would serve as a study and scientific library; and a photographic dark room. A sick bay would be required in the larger vessel only. Both vessels should be equipped with dynamos for electric light and the wireless apparatus. For general heating hot air apparatus is preferable, and fires or stoves would not be required except in the galley. A small portable hut and two double tents should be carried on each vessel. Two hand-sledges should also be provided, but dogs would not be necessary. Motor-boats and Norwegian "prams" should be added to the usual boat accommodation. Two detachable motors should also be carried by each vessel for use in the boats.

140. It was strongly impressed upon us that a single vessel which would provide accommodation for even the minimum navigating and scientific staff would be of an impracticable size for many of the purposes in view, and, in particular, for work in or near ice; but in accepting the recommendation in favour of the employment of two vessels we did not overlook the financial difficulties which might be expected to arise. We were, however, largely influenced by the opinion of the representative of the Admiralty that the expense of two vessels would be little, if any, greater than that of one larger ship, and that the proposal would not compromise the scheme *vis-à-vis* the Admiralty, whose interests in the matter are by no means limited to the purely hydrographical aspects of the expedition.

141. Among the positive advantages to be derived from the employment of two vessels instead of a single large vessel we noted :—

(*a*) that considerable economy would result from the fact that only the smaller vessel would require complete protection against ice;

(*b*) that accommodation would be available for the full staff it is desirable to employ;

(*c*) that it would be possible, when desirable, to make simultaneous observations in different localities;

(*d*) that it would probably increase considerably the area within which whales could be studied, and the number of whales which could be marked;

(*e*) that it would facilitate both the survey and biological work;

(*f*) that, as it might not be necessary to employ both vessels for a prolonged period of time, one of them could possibly be released and revert to the Admiralty at an earlier date, thereby reducing the expenses of the expedition in subsequent years;

(*g*) that, in the unfortunate event of damage to, or the loss of, one of the ships the scheme of work could still proceed. With the employment of a single vessel only, an accident would involve a serious gap in the work of the expedition. This, in view of the shortness of the working season, is a very important consideration.

142. It will be observed that it is recommended that motor-boats should be provided, and that two detachable motors should be carried on each ship. We were advised that the employment of two vessels of the size proposed would make it impossible to carry any steam launches. This was regarded as a matter of some considerable importance, as it was understood that motor-boats would be unsuitable for pursuing whales with a view to marking them. Such boats have already been tried by one of the firms engaged in the whaling industry, but their use has been abandoned, as it was found that the noise of the engines frightened the animals unduly. We were advised, however, by the representatives of the Norwgian Union of Whaling Companies that a sufficiently silent engine could be obtained; and we have, therefore, adopted the recommendation of the Sub-Committee that motor-boats of a speed of nine to twelve knots, with engines as silent as possible, should be provided in each ship. As a rule the whale catchers employed in the industry have a speed of fifteen knots, but we are advised that the speed recommended for the motor-boats will be adequate for pursuing the whales for marking purposes. The provision, in addition, of two detachable motors in each ship is, in our opinion, desirable, since, apart from other uses, they would enable the ships' boats to be driven to within pulling distance of the whales if, for any reason, the motor-boats should be found unsuitable or be temporarily unavailable for the purpose in view.

143. No useful purpose would be served by providing a harpoon-gun for shooting large whales, as it seems unlikely that it would be practicable for the biologists to make any detailed examination of carcasses alongside the ship; such work can more suitably be carried on at the flensing slips of the various land stations of the whaling companies. It is, however, essential that weapons suitable for marking whales should form part of the equipment of the expedition. A record of the discussion on this point with the representatives of the Norwegian Union of Whaling Companies will be found in Appendix XI., and our suggestions with regard to the form of weapon to be used will be found in paragraph 40.

144. The question whether any attempt should be made to provide a non-magnetic ship was discussed with Dr. S. Chapman, who appeared before us to give evidence on behalf of the Astronomer Royal (Appendix XXIV.). We were, however, unable to regard the proposal as feasible, in view of the expense and of the other purposes for which the ship would be required. Moreover, as the vessels would frequently be in the neighbourhood of land, there would be numerous opportunities of securing the greater accuracy attainable on shore.

145. We have also considered the question of employing an aeroplane in connexion with the research vessels or from land stations. In his evidence (Appendix II.). Dr. Bruce pointed out, for example, that the existence of certain islands in the Weddell Sea hinted at by Morrell and Ross might be ascertained by this means, although determination from the air of the presence of completely ice-clad islands would no doubt present considerable difficulty. On the other hand, as the sea in this particular area is only open at rare intervals, it is difficult for a ship to settle a point

of this nature. In addition, an aeroplane, if its use to any considerable extent were found feasible in the climatic conditions prevailing in the Dependencies, would be of great assistance in obtaining accurate surveys of land and sea. It would not be possible, however, to employ an aeroplane in connexion with research vessels of the size contemplated, as in neither case would the deck area afford sufficient accommodation; and we are unable to recommend that one should be attached to the expedition, at any rate in the first instance, even for use from land stations. The cost and upkeep of the machine and the pay of the necessary personnel would be considerable, and, as at present advised, we are of opinion that the funds available could be spent more usefully in other directions, especially in view of the doubt whether the use of an aeroplane is a practicable proposition in the regions in question. The researches in contemplation will, however, in all probability extend over a long period of years, and it may be anticipated that, as the aeroplane industry develops, the employment of a machine in this connexion will present fewer difficulties in the future. It may therefore, be found both desirable and feasible at some later date to add an aeroplane to the equipment of the expedition; and the possibility of making effectual use of observations from the air by this means should be borne in mind.

146. We desire to add that the Sub-Committee were anxious to have the advantage of the experience gained by Dr. Jean Charcot, the leader of the French expedition which visited the Antarctic in the "Pourquoi Pas?" Dr. Charcot was accordingly approached through the French Government, and furnished the Sub-Committee with references to the necessary documents and plans containing full details of the "Pourquoi Pas?" He also kindly consented to come to London for a personal interview if these particulars were insufficient. It was, however, thought unnecessary to trouble him to make a special journey for the purpose; but we desire to place on record our appreciation of his courteous response to the request for his assistance and advice.

Part X.—Management and Control of the Investigations.

147. We are of opinion that the whole question of executive control must be left in the hands of the Government Departments, viz., the Admiralty and Colonial Office, through which the expedition would be financed. If our proposals are adopted we recommend that an Advisory Committee should at once be set up to consider the steps necessary to give effect to them. We also recommend that the Admiralty and the Colonial Office should each appoint a member to the Committee, and that the remaining members should be appointed by the two Departments in consultation. It seems desirable that the other Departments which have nominated representatives on the present Committee, i.e., the Board of Agriculture and Fisheries, the British Museum, and the Department of Scientific and Industrial Research, should also be represented on the proposed Advisory Committee, with the addition of a representative of the Board of Trade or the Department of Overseas Trade, in order that the Committee may be kept in close touch with the commercial interests affected. In addition to the representation of Government Departments suggested above, we recommend that the Advisory Committee should be strengthened by being given power to co-opt, either in consultation with the Royal Society or otherwise, such experts as are best qualified to advise as to the scientific aims of the expedition, and also one or two other persons who have practical experience of the regions to be investigated and of the methods of conducting researches of the nature contemplated. It may be found advisable that this unofficial element should be attached to the Advisory Committee for special purposes only, and, in some cases, for a limited period of time.

Part XI.—Finance.

148. In the present unsettled state of prices it is impossible to estimate with any accuracy the cost of conducting the investigations recommended in the preceding paragraphs. We can only attempt, therefore, to afford some general indication of the expenditure involved.

149. The report of the Ship Sub-Committee (Appendix XXVI.) shows that the first cost of the two vessels would probably not be less than £85,000, and that the maintenance expenses would be from £25,000 to £30,000 per annum, exclusive of the scientific staff. The following naval staff, the cost of which is included in the above estimate, would be necessary for the two ships taken

together :—Two Commanding Officers, six Lieutenants, one Accountant Officer, one Engineer Officer, one Medical Officer, one Warrant Officer.

150. The cabin accommodation will be eleven cabins on the larger vessel and eight on the smaller. When provision has been made for the naval staff there will remain seven cabins available for the civilian scientific staff. It has been contemplated that cabin accommodation will be required for a permanent staff of not less than five scientists. This would leave available two cabins, which will be barely sufficient to provide for additional temporary staff and to facilitate the assembly of the scientific staff from time to time on board the larger vessel.

151. As regards the remuneration of the civilian scientific staff we are impressed by the fact that the salaries offered in such cases before the War were in general altogether incommensurate with the attainments of the persons engaged and the value of the services rendered. Therefore, even apart from the increased rates which must necessarily obtain on account of the present enhanced cost of living, we should recommend the payment of salaries at considerably higher rates; and, having regard to all the circumstances, we consider that a sum of not less than £3,000 a year should be allotted for the pay of the five scientists on the permanent staff of the expedition, in addition to any sum that may be required of them as messing expenses. In making this recommendation we have realized that the scientist in charge should receive substantially more pay than his subordinates. The annual expenses of the expedition, on the above basis of scientific staff, may therefore be estimated as from £28,000 to £33,000 a year, to which must be added (*a*) the cost of some additional subordinate scientific staff; (*b*) a small sum for messing expenses; (*c*) the expense of maintaining the scientific equipment; and (*d*) the expenses of the Advisory Committee to be appointed to control the expedition, including the cost of publishing its scientific results.

152. We have not included in the estimate any provision for the payment of salaries for staff temporarily employed and occupying the spare accommodation provided. It is possible that there are scientific bodies which may desire to take the opportunity to conduct special researches, and will be glad, if facilities are afforded, to avail themselves of the additional accommodation without imposing any extra charges on the funds of the expedition.

153. A provisional list of the scientific equipment will be found appended to the report of the Sub-Committee (Appendix XXVI.). In present circumstances it is impossible to give any reliable estimate of the total cost of the articles comprised in the list; but it is probable that the cost of equipping the expedition now in contemplation will not be less than £20,000.

154. As regards the incidence of the expenses of the expedition, we assume that the vessels and survey equipment will be provided by the Admiralty, and that the cost of maintenance and the pay of the naval staffs and crews will be borne by naval funds. Apart from the hydrographic aspects of the proposed researches, the primary objects of the expedition are concerned with the possibilities of economic development in the Dependencies, and, in particular, with the preservation of the whaling industry. Expenses incurred in connexion with these objects may, therefore, properly form a charge against revenue raised in the Dependencies. Local taxation of the whaling and sealing industries has hitherto been very light. Apart from the small annual fees payable in respect of leases and licences, the only direct taxes on these industries have been the export duties on oil and guano. The highest rate of duty hitherto imposed on oil is 3½d. a barrel, which represents an *ad valorem* rate of less than one-half per cent. even when based on the pre-War value of oil. Having regard to the much higher prices now obtained for oil, it seems clear that a substantially increased revenue can be obtained from the industry without imposing any undue burden upon it, and it may be anticipated that it will prove sufficient to cover the salaries of a staff of scientists, a considerable portion, if not the whole, of the cost of the initial scientific equipment, and also the expenses of maintaining this equipment. We are not in a position to make any definite recommendations as to the amount of additional taxation which should be imposed for these purposes.

155. In concluding this section of our report we desire to invite attention to the representations made to us by Dr. Bruce in the penultimate paragraph of his letter of the 14th May, 1918 (Appendix I.), as to the publication of the reports of the Scottish National Antarctic Expedition, which it has not been possible to complete

owing to the lack of funds. Apart from other considerations, there can be no doubt that it would materially assist further researches if complete reports of the Scottish expedition were available, and we recommend that additional financial assistance should be afforded for the purpose.

Part XII.—Summary of Recommendations.

156. We summarize the recommendations made in this Report as follows:—

Part II.—The Whaling Industry.

1. A system should be devised for marking whales (paragraph 40).

2. The food of whales, whether consisting of plankton or fish, should be carefully investigated (paragraphs 42 *et seq*).

3. The migrations of the sperm whale to southern waters should be investigated (paragraph 45).

4. We recommend that the present system of securing statistical returns from the whaling companies should be continued and extended, and that special attention should be paid in the statistics to the points enumerated in paragraphs 47 to 51 inclusive (paragraphs 46-51).

5. The question of the species of whales to be found in the southern waters should be studied by competent zoologists (paragraph 52).

6. An experienced zoologist should be deputed to work for some time at one or more of the whaling stations (paragraph 53).

7. Observations should be made on living whales, including observations made at the breeding grounds, and on the paths of the migrations of whales (paragraph 54).

8. The habits of the killer whale should be investigated (paragraph 55).

9. Direct observations should be made of the methods adopted for hunting whales (paragraph 56).

10. The Committee consider that whaling rights should be confined, as far as possible, to annual licences, and should in no case be granted for a long term of years (paragraph 59).

11. The utmost economy must be observed in the utilization of all whale products, and every effort should be made to prevent the capture of more whales than can be completely utilized (paragraphs 61 and 63).

12. The use of floating factories should not be permitted more than is absolutely necessary (paragraph 62).

13. Attempts should be made to train British whaling crews in the waters of the United Kingdom (paragraph 68).

14. The employment of British crews in the whaling industry should be encouraged by allowing one or more companies to employ an extra whale-catcher, on condition that the crew should be British (paragraphs 69 and 70).

15. The manning of floating factories and shore stations by British labour should be encouraged (paragraph 71).

16. The scientific staff to be employed on the investigations recommended, should get into touch with the chemical staff employed by manufacturers, in order to ascertain whether there are any chemical problems which should be studied at the whaling stations in the Dependencies (paragraph 75).

17. Investigations as to whale meat should be conducted in the United Kingdom, and samples of whale meat should be sent to London experimentally (paragraph 84).

Part III.—The Sealing Industry.

18. It would be well to prohibit the capture of Weddell's seals in South Georgia (paragraph 90).

19. An experiment should be made, with a view, to re-establishing the fur seal in the Dependencies by the introduction of specimens from elsewhere in the South Atlantic (paragraph 94).

20. Pelagic sealing should be prohibited (paragraph 96).

21. While it is unnecessary at present to make any change in the existing policy for dealing with sea elephants, it is suggested that the system of farming the fur seal at the Pribylof Islands might be adopted with the necessary modifications in dealing with this animal (paragraphs 97 and 98).

22. Study of the life history and habits of the seals of the Dependencies should form part of the work of the biologists attached to the proposed expedition (paragraph 99).

Part IV.—Fish, Penguins, and other Animals.

23. A survey of the waters of the Dependencies should be made with the view of locating fisheries which are likely to prove profitable (paragraphs 100 *et seq*).

24. The position of the stock of penguins should be accurately noted from time to time, and any licences that may be granted for taking penguins or their eggs should be limited in accordance with the results of careful observation (paragraph 107).

25. Every encouragement should be given to the establishment of the reindeer in South Georgia (paragraph 108).

26. The introduction of smaller mammals into the Dependencies should be discouraged, and the brown rat especially should be exterminated if possible (paragraph 110).

Part V.—Hydrography.

27. A complete hydrographical survey of the Dependencies is necessary, both in the general interests of navigation and in the local interests of the whaling industry, and also to deal with the scientific questions referred to in paragraphs 120 to 129 inclusive (paragraphs 113 *et seqq.*).

Part VI.—Meteorology and Magnetism.

28. A carefully selected meteorologist should be detailed to accompany the proposed expedition (paragraph 133).

29. Magnetic observations should be made in the course of the hydrographical survey (paragraph 134).

Part VII.—Geology and Mineralogy.

30. A geologist should be attached to the expedition, at any rate for a limited period (paragraph 136).

Part VIII.—Botany.

31. The biologists of the expedition should devote some attention to the botany of the Islands, particularly in relation to the question of the acclimatization of animals (paragraph 137).

Part IX.—Research Vessels.

32. Two special vessels should be employed to carry out the researches proposed, to be provided with motor-boats, and the crew and equipment recommended in paragraphs 139 to 143 inclusive (paragraphs 139 *et seq*).

Part X.—Management and Control of Investigations.

33. The executive control of the investigations should be left in the hands of the Admiralty and Colonial Office, who should set up an Advisory Committee in the manner suggested in paragraph 147 to give effect to the proposals made in the Report (paragraph 147).

Part XI.—Finance.

34. The remuneration of the civilian scientific staff should be provided for at considerably higher rates than have been given in the case of previous expeditions. Provision should also be made for publishing the scientific results of the proposed expedition (paragraph 151).

35. Expenses incurred in connexion with the economic development of the Dependencies, and, in particular, with the preservation of the whaling industry, may properly form a charge against revenue raised in the Dependencies, and additional taxation may rightly be imposed upon the whaling and sealing industries for the purpose of meeting such expenditure (paragraph 154).

36. Financial assistance should be given to enable the proper authorities to publish the complete Reports of the Scottish National Antarctic Expedition (paragraph 155).

157. We desire to record our indebtedness to our Secretary, Mr. H. T. Allen, who, in spite of the heavy pressure of other duties, has been of the greatest assistance to us at all stages of our inquiry, and also in the work connected with the compilation of the present report.

P. C. LYON (*Chairman*).
J. O. BORLEY.
E. R. DARNLEY.
S. F. HARMER.
CHAS. V. SMITH.

H. T. ALLEN
(Secretary).

27th August, 1919.

APPENDIX I.

LETTER READ BY DR. W. S. BRUCE, F.R.S.E., TO THE COMMITTEE ON THE DEPENDENCIES OF THE FALKLAND ISLANDS.

GENTLEMEN, 14th May, 1918.

IN the first place, I have to thank you for the compliment you have paid me by asking me to meet you for the purposes of consultation generally, and in asking me to give you the benefit of any experience I may have had and advice at an early stage of the Committee's proceedings. I am only too glad to do what I can to help the Committee in any way possible in a subject and part of the world with which I have been associated for twenty-six years, and first visited in 1892, and that in connexion with a British whaling and sealing expedition.

My only diffidence is that, in dealing with the subject as a whole, I am somewhat in fear of trespassing on the special regions for which different members of the Committee have obviously been specially appointed; but on the other hand it is perhaps the reason why I should have special confidence that any remarks I do make will be specially well-balanced and used where they should be used.

The Dependencies include, as the Committee knows, all islands and territories:

(*a*) Between 20° W. and 50° W. south of 50° S., which include among known lands from east to west:—

(1) Coats Land (the greater part);
(2) Sandwich group;
(3) South Georgia;
(4) South Orkneys;

and a greater part of

(5) Southern Ocean, including the greater part of the Weddell Sea.

(*b*) Between 50° W. and 80° W. south of 58° S., which includes at least all known lands south of Cape Horn, namely:—

(1) Graham Land, with its many adjacent islands to Charcot Coast.
(2) South Shetlands.

(*c*) Presumably all unknown seas or lands south of the above known regions to the South Pole.

This region was first visited by Amerigo Vespuccio in 1501-2, Sir Francis Drake in 1578, Dirck Gherritz in 1599, Antonyo de La Roche in 1675, Father Louis Feuillée in 1709, Commodore Jacob Roggewein in 1722, Sieur Ducloz Guyot in 1756, and others.

Captain Cook twice visited this region, first in 1769-70, when he reached 60° 10′ S. in 74° 30′ W., and again in 1775, when he sighted and took possession of South Georgia, and a little later discovered the Sandwich group. Cook first reported the whales of South Georgia. Captain James Colnet, who had previously sailed with Cook, sailed north-west of South Georgia in 1793-4, and confirmed Cook's report of an enormous number of whales, especially black whales, there, and refers to "many profitable voyages" having been made there for sealskins prior to 1793. He also reached 61° S. in 70° W.

Mr. William Smith, in the snow "Williams," of Blyth, discovered and took possession of the South Shetlands in 1819, landed and made at least five voyages thither. Smith reported whales there also; and enormous herds of fur seals, sea elephants, and other seals.

Mr. Edward Bransfield, R.N., next visited the South Shetlands, in 1819-20, in command of the "Williams," then chartered by Captain W. H. Shirreff, R.N. (H.M.S. "Andromache") for the purpose. Mr. Smith sailed as master. Bransfield made the first good chart, landed, and took official possession, and discovered the first part of Graham Land, calling it "Trinity Land," after the Trinity Board, in January, 1820.

The first seals definitely taken for economic purposes appear to have been by the "Juan Nepomuceno," that landed 13,000 in Buenos Ayres, in February, 1820, and by the United States brig "Hersilia" during the same season, when Bransfield was then on the fourth voyage of the "Williams."

Next season (1820-21) there followed at least twenty-two British and twenty-five American sealing vessels, and in 1821-22 at least twenty-four British and twenty American sealing vessels, and these forty-six British and forty-five American, or ninety-one vessels in these two years, practically exterminated the fur seal and other seals, so that full cargoes were not even obtained during the second year. This is a most important economic disaster that should not be forgotten, and should at least not be allowed to be repeated.

Only occasional voyages for sealing—few and far between—have been made since to the South Shetlands, and mostly by American sealers.

Admiral Bellingshausen visited and charted the south side of South Georgia in 1819, and met British whalers there; he discovered the Traversy Islands, and definitely determined that the Sandwich group were insular, and added importantly to Cook's survey. On his return from his important cruise he steered for and reached the South Shetlands in 1821, and made the best survey that exists of its southern coasts. Admiral Bellingshausen's work classes with that of Cook, whom he obviously esteemed.

Mr. George Powell, in the "Dove," in company with Mr. N. B. Palmer in the "Munro," discovered and charted the South Orkneys in 1821-22, while he and others —notably Weddell, Fildes, Hoseason, and Sherratt, of the many British sealers— roughly charted the South Shetlands and Trinity coast, Graham Land, and the north and south end of Belgica Strait. Weddell also charted the South Orkneys, and reached 74° 15′ S., 37° 17′ W.

The records of American sealers are very disjointed, but apparently Palmer and others made high latitudes both along the east and west coasts of Graham Land, and Mr. Benjamin Morrell crossed the seventieth degree of latitude in the Weddell Sea, in 1823, and reported land said to have been discovered by Johnson in 1822.

Mr. John Biscoe, in 1832, discovered the west coast of Graham Land, which was named and sketched by him. He also visited the South Shetlands.

Thereafter Wilkes, d'Urville, and Ross all visited this region, and Ross especially made important discoveries, and specially noted the presence of whales in Erebus and Terror Gulf, which fifty years later led to the dispatch of four vessels of the Dundee whaling fleet to Erebus and Terror Gulf, which I accompanied as naturalist in 1892. Norway, hearing of the proposed departure of the Dundee whalers, also sent Captain Larsen, whom I first met in Erebus and Terror Gulf in 1892.

As a whaling enterprise it was a failure, but we took over twenty thousand sealskins (true seals), and had full ships of seal blubber. Captain Robertson was the most enterprising of the Dundee whaling masters. He harpooned and made fast for many hours a monstrous blue whale, which, on account of its enormous breadth and worn-out dorsal fin, Ross had possibly mistaken for a black whale, unless, perchance, he had actually seen a nordkaper.

This was the beginning of modern Antarctic exploration and of the present great whaling industry, which has led to the Dependencies of the Falkland Islands being a mine of wealth, and which led to my choosing Captain Robertson as master of the "Scotia" ten years later.

The next step was a visit to Edinburgh of an agent of Mr. Svend Foyn, to see Mr. Burn Murdoch and myself. Mr. Burn Murdoch was also on board the "Balæna," and had met Captain Larsen with me in Erebus and Terror Gulf. A meeting was held in the Royal Scottish Geographical Society's rooms, in which the Norwegian type of whaling, then unknown in Britain, was advocated and rejected. There were present, among others, Sir John Murray besides Mr. Salvesen, but what did a scientist and an artist know about whaling or the Norwegian expert associated with them! Sir John Murray, with others, was thus persuaded against it. Larsen, however, went a second sealing voyage the following year, and was subsequently chosen by Dr. Nordenskjöld as master of his vessel, the "Antarctic."

Fortunately for the Falkland Islands Colony the "Antarctic" was wrecked, and all hands were rescued by the Argentine sloop "Uruguay." Larsen became the Polar hero in Buenos Ayres; anything he said was believed in, and consequently they believed in his Norwegian story of whaling, financed him, and immediately started the Dependencies' whaling industry, which might have been started twelve years earlier from Britain.

Following the terms of reference appended to Mr. Allen's letter* D.C.3 to me of the 1st May, 1918, I presume, however, that the Colonial Office do not intend to promote a South Polar expedition to the Weddell Sea or Bellingshausen Sea area, although there are certainly many British subjects, after the more hazardous experiences they are undergoing at present in Europe and elsewhere, who will doubtless be more than ready to take part in the lighter and thoroughly congenial task of a Polar expedition, but I suppose that the Colonial Office suggests carrying out such investigations as are certain to aid the economic prospects of the Colony of the Falkland Islands and its Dependencies. These are obvious, particularly in the neighbourhood of:

* Not printed

(1) Sandwich group,
(2) South Georgia,
(3) South Orkneys,
(4) South Shetlands,
(5) North-west of Graham Land,

and seas adjacent.

I therefore beg to suggest that:

1. *The Cartography and Sailing Directions* of the whole region is the most pressing and important work to be carried out. Commerce and science are dependent, and will be more dependent, on the detailed hydrographic survey of the region, including, especially, a good account of sheltered anchorages, as land stations are more especially important in the future than they have been in the past.

The Sandwich group call for special attention in this direction, as they have not been surveyed since 1819 by Admiral Bellingshausen, except for some rough sketches by Captain Larsen. The definite knowledge concerning at least one harbour is most important at this group of islands, on account of the tempestuousness of the locality making landing too often entirely impossible. There is the likelihood of one, if not two, anchorages at Southern Thule, and not impossibly at Bristol Island, or some other more northern island.

I will afterwards specially refer to the importance of knowing a good harbour at the Sandwich group for scientific, as well as economic, purposes.

(*a*) South Georgia requires similar attention for the proper needs of its whaling industry, especially in the south-east.

(*b*) In the South Orkneys the accurate survey of Coronation Island is required, and additional hydrographic work to that initiated by the "Scotia."

(*c*) In the South Shetlands there are practically no reliable and up-to-date surveys, except those of Admiralty Bay and Deception Island.

(*d*) In Graham Land the Belgian, Swedish, and French surveys, along with those of Ross and d'Urville during last century, are the only reliable ones.

Besides coastal work, much additional bathymetrical and deep-sea deposits work requires to be done in the whole of this region south of 50° S., as well as, if possible, between the Sandwich group and Bouvet Island. The detailed mapping out of the important "*rise*" which appears to exist between Falkland Islands, Shag Rocks, South Georgia, Sandwich group, South Orkneys, South Shetlands, and Graham Land, is a most important oceanographical and geographical fact to establish or refute. Though a little outside the eastern boundary of the Dependencies territory, its relation with the "*Scotia Rise*," south of Gough Island, and with a possible "*rise*" south-westward of Bouvet Island, is also most important. Here, also, a further geographical problem is the confirmation or refutation of the Thompson Island group. Rock specimens from Bouvet and Thompson Islands are essential in the elucidation of the geology of the southern hemisphere. There may also be one or more islands yet undiscovered on the "*Scotia Rise*."

The "*deep*," first hinted at by the "Challenger," with two soundings of two thousand nine hundred fathoms north of 40° S., and confirmed by Swedes and Germans further south, should, oceanographically, and in honour to the "Challenger's" initial work, be further mapped out, as I suggested some years ago in the *Scottish Geographical Magazine*. I strongly urge that this be done, along with research, which I will hereafter suggest should be carried out at Gough Island, or possibly Tristan d'Acunha, in connexion with work in the Dependencies' actually defined area. This cruise could be carried out by a zig-zag course from Port Stanley to Gough Island, between 52° S. and 38° S., during the winter, when higher southern latitudes will be largely closed for purposes of navigation, not only on account of temperature conditions, but more particularly on account of the stormy, long, dark nights and presence of much floating ice, often invisible. But it should be done.

Detailed bathymetry of Drake Strait, east and west of the present solitary line of soundings, between Cape Horn and South Shetlands, and of Bransfield Strait, should be carried out. Possibly some ordinary survey vessel might be employed for some of the deep-sea work, besides any vessel being specially selected for Dependencies' work.

In summer it would be useful to use aircraft to definitely settle, if possible, the existence or non-existence in the Weddell Sea of any "cluster of islands," hinted at by Ross's officers in 1843 and by Morrell, farther south, in 1823, and not yet fully

disproved either by the "Deutschland" or "Endurance." It ought to be possible to do this easily without serious ice navigation for the principal vessel, probably a wooden one.

2. Next comes *Meteorology and Magnetism*. Meteorology is of the utmost scientific importance, but, economically, its great value has been most forcibly demonstrated by the *facile princeps* Antarctic meteorologist, Mr. R. C. Mossman, who has established, since the foundation of the Scotia Bay meteorological station in 1903, that that station controls the cereal belt of the Argentine Republic. The present rich wheat crop now, I believe, on its way to ourselves and our Allies, was forecasted three years ago, a truly wonderful world-economic result of Antarctic meteorology, and well worth the £70,000 spent on the Scotia Bay observatory by the Ministry of Agriculture of the Argentine Republic during the last fourteen years. This emphasizes the necessity of hydrographical survey, especially in relation to harbours and anchorages, for one of the most important places where we require a good anchorage is Southern Thule, which Mr. Mossman considers of first importance. with Wandel Island or neighbourhood, and Gough Island or Tristan d'Acunha, as new meteorological stations, in addition to those already existing at South Orkneys, South Georgia, Falkland Islands, and Tierra del Fuego. Peter Island, just outside the area of the Dependencies, would be a valuable site for a station, but possibly too difficult. The reason is the action and reaction of two Antarctic cyclonic areas, and two Atlantic and Pacific Ocean anticyclonic areas farther north, which have intimate relationship with the rainfall in Chile and Argentina, as well as other climatic effects in Kimberley, the Nile, even Iceland, and probably even forecast the monsoons of India. The Gough Island station will probably be of great service to South Africa in weather connexion. I must detain the Committee no longer on this entrancing subject, this Valhalla of economic science, and only further suggest that magnetic work should be associated with these stations, besides other sciences—especially local oceanographical work in relation to salinity, temperature, tide, and current work, besides biology and local geology.

3. Next we have *Biology*, especially the life, but also a knowledge of species, of animals, and plants, of very direct relationship to whaling and sealing industries. Here, again, the station idea, as suggested by Dr. R. N. Rudmose Brown in his important paper, entitled, "The Problems of Antarctic Plant Life," in 1911, is again undoubtedly important. We especially require good marine biological laboratories, such as have existed in many places now for several years past, and which should be established in sub-Polar, and even in Polar, regions, like that at Disco, in Greenland, by the Danes. Why not share the luxuries of a meteorological magnetic observatory? I am sure Dr. Harmer and Mr. Borley will thoroughly agree with this suggestion.

Here the food material of whales, seals, and other animals could specially be studied, while the species and direct comparative anatomy of whales should be studied in detail at the different whaling stations themselves.

Migration and breeding of whales is most important, and even a killer of whales, like Mr. Salvesen, refers to the serious diminution at present extending under strenuous war conditions, and the likelihood of an even greater demand for whale oil after the War. May I invite the Chairman to taste a sample of whale oil I have brought with me—hardened, whitened, pure, odourless, and tasteless—the future of our margarine supply.

And here a word as a biologist. Let us take heed of the lesson the fur seal hunters of 1820-22 ought to have taught us, and protect the Dependencies' whales. Why not begin by diminishing foreigners' licences as soon as possible, and stop the present waste of by-products. Whale flesh is more valuable as meat than as rich guano. And why not resuscitate the fur seal fisheries, which is just as possible in the South Shetlands as at Pribilof? Don't kill a single fur seal for, say, twenty years. Attempt to breed young on suitable places at the South Shetlands, and possibly South Georgia, as I advocated with Sir Roger Tuckfield Goldsworthy twenty-five years ago, and they would likely return to the land of their birth every year, as their progenitors used to. Captain Smith graphically told us in 1819-20 that they were "stowed in bulk" at the South Shetlands. Let us attempt at least to stow them in bulk again. Probably the Falkland Islands fur seal fisheries might also be increased, and there are special suggestions that one could make in this direction.

Other fishery questions are there for the zoologist on the spot that require to be investigated. especially that of food fishes on the Burdwood Bank, and the strange migration of enormous shoals of herrings at the Falkland Islands, and other fishes

there and elsewhere. The problems connected with the possible commercial utilization of penguins raise complex issues in the balance of animal life. Any such measures, moreover, would rapidly lead to the extermination of the penguins. For these reasons no steps in this direction should be allowed before the matter has been referred to biologists. Similarly the introduction of exotic animals should be carefully controlled. Foxes, bears, and other carnivores should be prohibited. Reindeer have been introduced in South Georgia apparently with success, but it is impossible to say at present what effect they may eventually have on the fauna and flora.

Besides station work, there is much biological work to be done on board ship, and especially on the migration of whales, whose course should be followed up as closely as possible. In this connexion salinity and temperature investigations should be closely associated, beside a certain amount of dredging and the like.

I have not forgotten deep-sea zoology, but will the Colonial Office face the time and money required for it?

Botanically, the problems presented are purely of a scientific nature. There is no likelihood of plants of economic value being capable of cultivation, even at South Georgia. At the other Dependencies it is out of the question. However, the investigation of plankton in relation to fish and whale migration is a problem that has scarcely been touched.

4. *Geologically*, there is much work of importance, besides purely scientific facts and problems. The mineralogy of South Shetlands would possibly repay investigation. Graham Land should certainly be further investigated, and might contain minerals of value. Nothing is known of the geology of the South Sandwich group. South Georgia and Coronation Island have been little examined.

For carrying out the investigations I have spoken of a good wooden ship of only moderate tonnage should be used, along with one or more smaller vessels of the whale-hunting type. Possibly, also, arrangements might be made to carry individual scientists on some of the whalers.

May I finally suggest that no meteorological plan be adopted without the complete approval of Mr. Mossman. There is no living meteorologist who has greater practical and theoretical handling of Antarctic meteorology than Mr. Mossman, and very especially any such question arising within the Dependencies' area. In matters geographical and biological I would similarly recommend that Dr. Rudmose Brown's wide knowledge of this special region, and Antarctic problems generally, should be fully utilised in connexion with many problems that may arise. The fact that both have Arctic, as well as Antarctic, scientific records during the last sixteen years, and have continually and ably handled Antarctic questions, and especially any arising in this very region, cannot but be of the highest possible value. There are several other younger men with considerable experience if they pull through the War.

May I also urge that your Committee should ask the Secretary for the Colonies to do all that is possible in advance of any such expedition to promote and complete the publication of the scientific results of the pioneer British expedition that actually did most of its important work within the limits of the Falkland Islands and their Dependencies. I refer to the Scottish National Antarctic Expedition and the "Scotia" results (1902-4). So far only six out of twelve volumes have been completed, and resultant charts of an important character have not been published, because the Treasury have, in spite of most urgent scientific appeals from the highest possible sources, only granted half the minimum sum required to complete these reports. Yet it has been shown that the results of this pioneer expedition, for which only another £4,000 is required, have already induced the Government of the Argentine Republic to spend a sum of not less than £70,000 to continue part of the work of the "Scotia," vastly important for the agriculture of Argentina. While very largely out of the results of the "Scotia's" work, the remarkable prosperity of the whaling industry of the Falkland Islands Dependencies has arisen, and results have been shown that are likely to be of importance to South Africa, and even India and Egypt, and especially for the present proposed investigation.

Finally, I offer to any workers whom the Secretary for the Colonies may appoint, any facilities and help the Scottish Oceanographical Laboratory can afford. All the records, biological and geological collections of the "Scotia" and those of other expeditions are there in good order, and fit for handling, besides geological collections from South Georgia, South Shetlands, and Falkland Islands, and others, as well as original meteorological, tidal, and other data.

I have, &c.,
WM. S. BRUCE.

14th May, 1918.

APPENDIX II.

NOTE OF DR. BRUCE'S REMARKS AT THE DISCUSSION OF HIS LETTER OF THE 14TH MAY, 1918.

1.—DISCOVERIES.

DR. BRUCE emphasized the fact that, although the first discovery of the mainland has usually been attributed to N. B. Palmer (1820-21), Edward Bransfield, R.N., discovered and named it Trinity Land, 1819-20, actually 30th January, 1820, or a year before Palmer's voyage. Subsequently Biscoe discovered the west coast in 1832, and named that part Graham Land, which has for some time been used as a name for the whole mainland, including Trinity Land or Coast. The American sealers boasted of the discovery of Palmer Land by N. B. Palmer, but Bellingshausen, who met Palmer off Morton Strait, South Shetlands, in January, 1821, does not acknowledge this or show it on his chart. Captain McFarlane, in the brig "Dragon," of Liverpool, landed on Trinity Land, 1820-22. Captain J. Usher, in the schooner "Caraquette," of Liverpool, also moored there for a few days and landed, 1820-22. The chief officer and ten of the crew of the "Lord Melville," of London, wintered in a strong house with ample supplies at Esther Harbour, King George Island, during the winter 1821. Fildes, Powell, Weddell, and others have left useful records during 1820-23.

2.—FUR SEALS.

The record of the first landing of fur sealskins, viz., 13,000, was in Buenos Ayres, and is found in the correspondence of Commodore Hardy with the Admiralty. Dr. Bruce has not been able to trace any further record, but is having inquiries made in Buenos Ayres with regard to the "Juan Nepomuceno."* At least forty-six British vessels, besides at least forty-five American vessels, visited the South Shetlands in 1820-22; and Dr. Bruce said that he had traced the names of these, as well as their masters and other particulars, including the particular nature of some of the cargoes brought back.

It is recorded that, during the season 1820-21 :—

Cutter "Eliza," Captain George Powell, brought back 16,000 to 18,000 fur sealskins to London, on 5th April, 1821.

The "Salisbury," Captain Hodges, Liverpool, which arrived in London on the 16th May, 1821, had 9,000 fur seals on board.

Ship "Indian," Captain Spiller, Liverpool, took 10,000 to 12,000 sealskins, by the 3rd January, 1821, and a total of 20,000, arriving in London on 7th June, 1821.

Brig "George," of Liverpool, had taken 9,000 seals by the 3rd January, 1821, and, continuing to kill 1,000 a week, took a total of 18,000 in the season, arriving at Deal on 1st June, 1821.

Brig "Dragon," Captain McFarlane, Liverpool, took 5,000 by 16th December, 1820, after being at the South Shetlands seven weeks, and arrived at Buenos Ayres on 11th April, 1821.

Ninety-five thousand sealskins were taken in the season of 1821 by five British crews off a small spot of land known as Shirreff Cove, South Shetlands, which is shown on the most recent Admiralty chart slightly west of the northern point of Livingstone Island. This would appear to be a definite record.

These records have been culled at the cost of much labour from the shipping intelligence in the daily newspapers of the period.

The season of 1821-22 is interesting in some of its records. The following are two very detailed accounts from the shipping records of the day, and show the rapid decline of the sealing industry :—

The ship "Ann," Captain J. Kitchen, of Liverpool, reached the sealing ground there prior to 10th November, 1821. There is no record of her departure, but she returned by Bahia, to Prince's Dock, Liverpool, on the 1st August, 1852. Her cargo consisted of (*from New South Shetland*) 1,429 sealskins, 13 tons sea elephant oil, (*from Bahia*), 221 bags cotton, 1,100 coco-nuts, and 4 boxes oranges.

The "Dragon" found plenty of sea leopards and sea elephants, but no fur seals, on Trinity (Land) Coast.

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* Dr. Bruce has, since 14th May, 1918, received the following record from Buenos Ayres, through Mr. H. G. A. Mackie, British Consul-General there, who finds that the "San Juan Nepomuceno" was an Argentine polacre, under the command of Captain Carlos Timblon, and that she had a cargo of 14,600 sealskins, consigned for transhipment to Don Adam Guy. She arrived in Buenos Ayres on 22nd February, 1820. The American brig "Hersilia," under command of Captain Sheffield, similarly arrived on 27th February, with a cargo of sealskins.

The "Caraquette," Captain J. Usher, was still at South Shetlands until 1st April, 1821, and arrived at King's Dock, Liverpool, 10th October, 1822. Her cargo was (*from Buenos Ayres*) 2,317 horse hides, 7 bales of horse hides, 1,564 cow and ox hides, and (*from the New South Shetland*) 487 sealskins and 40 gallons leopard oil.

Mr. Lyon inquired whether these were all sealing vessels. Dr. Bruce said that they were all sealers. There were odd whalers, but no such detailed records of these appear as of these sealers' voyages which Dr. Bruce has recorded.

Dr. Bruce had also many similar American records of fur seal catches. Five American vessels, namely, sloop "Hero," brigs "Frederick" (Pendleton), and "Hersilia" (Sheffield), schooners "Express" (Williams), "Freegift" (Dunbar), between 27th November, 1820, and 12th January, 1821, are recorded as securing 50,598 "prime fur skins" at the South Shetlands.

Thirteen other American vessels are reported having 53,800 fur sealskins on board by 26th February, 1821 (*season* 1820-21), besides other records.

On 9th May, 1821, 65,000 sealskins arrived at Stonington, and were advertised for sale on 23rd May. In replying to Dr. Harmer, he said that he did not consider Weddell's estimate of 320,000 fur seals being taken from the South Shetlands during 1820-21, 1821-22, and 940 tons of sea-elephant oil, as excessive. He mentioned, also, a rather interesting American record of Captain Robert Johnson, who was the master of the schooner "Wasp," in 1821-22, the year before Morrell sailed in her as master. Great doubt has been thrown on the records of Morrell on account of the extensive region he has said he had explored; but he is not so unreliable as many suppose, for the "Wasp" was undoubtedly a very fast sailing schooner. She reached New York from Falkland Islands on 31st May, 1822, in forty-eight days—the best record known, whilst the brig "Nancy," Captain Upton, took seventy-three days to Salem from South Shetlands, arriving there on 27th May, 1822.

The reason why the Dundee whaling enterprise was a failure in 1892-93, was that the four Dundee whalers, and one Norwegian whaler, were equipped for bow-head whales (*Balæna mysticetus*), and had not the modern vessels, guns, and gear required for dealing with finner and other whales.

3.—Exploration.

As regards "exploration," Dr. Bruce had only contemplated exploration in the region of open and light ice, outside the border of the heavier ice, and not penetration towards the South Pole. There are other reasons for work outside the region, which can be touched upon later.

4.—Hydrography.

Dr. Bruce regarded hydrography as of first importance.

Dr. Harmer said he would have thought the investigation of the whaling problem the chief point. Dr. Bruce regarded survey as a condition precedent to the investigation of the whaling problem. There must be good harbours known into which the whales and whalers can be taken with safety.

Dr. Harmer pointed out that whales are being hunted from various places already in South Georgia.

Dr. Bruce said that in this respect he had very much the same ideas as Dr. Harmer—as regards the importance of investigations regarding whales.

Dr. Harmer inquired whether Dr. Bruce meant that cartographical work is so important that every effort should be made to carry it out first.

Dr. Bruce replied that the difference was simply one of point of view as to the order of the various subjects, but that it is essential not to omit cartography when making the whaling investigation. Hydrographic survey must be carried out as a basis of whaling and other scientific work. Mr. Salvesen has, for instance, very strongly urged that there should be a good chart of South Georgia for the needs of whaling, and it is commercially very important to get the whole of that island accurately charted.

5.—"Scotia" Survey.

The "Scotia" surveyed Laurie Island and took five hundred soundings during the winter round the coast, but there is still much more hydrography to be done there, as well as around Coronation Island.

Only two modern surveys in South Shetlands exist, viz., that of Deception Island and Admiralty Bay. Otherwise everything is rough sealer's work, except Bransfield's survey of George Bay and Kendal's survey of Deception Island.

More reliable work has been done down the west coast of Graham Land than in the South Shetlands. Charcot's hydrographic work is the most important work that has been done there.

6.—"Scotia" Rise.

Dr. Bruce explained that a "rise" is a submarine ridge of less than two thousand fathoms depth, a "deep" is over three thousand fathoms, and that the mapping out of the details and relationship of the Andean-Graham Land Rise to the "Scotia" Rise and Bouvet Island is a very important oceanographical and geographical problem. Any scientific work to be done cannot be confined rigidly within the boundaries of the Dependencies.

Such a further problem is the confirmation or refutation of the Thompson Island group. The "Scotia" found indications of the possibility of the existence of one or more islands on the Scotia Rise in relation to the presence of birds.

As regards the existence of certain islands in the Weddell Sea, hinted at by Ross, and also by Morrell, Dr. Bruce said the course of the "Endurance" lay seventy miles, and the "Deutchland" ninety miles, from the reported location, and it is not practicable to make out land of a moderate height at that distance. If the sea were open a ship could determine the point, but in that area the sea is only open at rare intervals. An aeroplane could, however, easily fly over the area and determine this, although the determination from the air, as Captain Smith suggested, of the existence of completely ice-clad islands, might present considerable difficulty.

7.—Meteorology.

Dr. Bruce produced a paper by Mr. R. C. Mossman on "Southern Hemisphere Seasonal Correlations," and drew attention to the chart, in which are marked out three high- and two low-pressure areas, which have an intimate relationship with one another, upon which the rainfall of the cereal belt of Argentina depends. In this pamphlet Mr. Mossman also shows that the barometer curve of Laurie Island is exactly the reverse of that for Stykkisholm, Iceland, and he also refers to correlationship between the South Orkneys and Kimberley, South Africa, as well as South Georgia and South Orkneys with South America, and South America with Perth, Western Australia. Mr. Mossman also shows that the temperature prevailing over South Africa is related in some way to the antecedent conditions in the great Southern Ocean. Upon the distribution of ice in the Weddell Sea many other correlations also depend. Dr. Bruce also referred to several other Antarctic meteorological records by Mr. Mossman, up to his address to the Royal Society of Edinburgh in May, 1918. Mr. Mossman emphasizes the extreme interest of a meteorological station on Peter Island, which lies just outside the boundary of the dependencies, and somewhat difficult of access, besides Southern Thule, Wandel Island, and Gough Island, or Tristan d'Acunha. Gough Island was more important biologically and geologically.

Dr. Bruce expressed the view that a biological laboratory should be attached to every meteorological observatory, also that, if practicable, a naturalist should be carried by each whaling vessel, a matter which he had discussed with Mr. Salvesen, who was evidently quite ready to consider what his firm could do in this direction.

8.—Food Fishes.

The best trawling record of the "Scotia" was obtained on the Burdwood Bank. And herrings (*Clupea fuegensis*) were so numerous on one occasion in Port Stanley that they entirely hid a simple ring net used to catch them with.

9.—Plankton.

Plankton investigation, especially in relationship with temperature and salinity observations, was most important in connexion with whaling, sealing, and fishery investigations, as well as the nature of the bottom, in such places as the Burdwood Bank.

10.—Deep Sea Dredging.

Dr. Bruce had not referred to the matter of deep sea dredging in his memorandum, as he was not clear that such work was contemplated. But, if the Colonial Office was prepared to face expenditure of time and money required, he favoured dredging and other work in the great depths to the north of South Georgia, as well as in the shallower waters round the dependencies and islands mentioned.

11.—Economic Geology.

There seems to be a decided hint of a considerable supply of copper in the South Shetlands and Graham Land. There is an early American record of coal in the South

Shetlands, which is said to be better than Newcastle coal, and possibly other minerals of value may be found.

12.—Research Ship.

Dr. Bruce suggested a wooden ship of moderate tonnage—about one thousand two hundred tons or one thousand five hundred tons—about the size of the "Princesse Alice" or "l'Hirondelle," the Prince of Monaco's oceanographical research vessels, or a smaller vessel of the "Scotia" type, if funds were insufficient for the larger one. The "Scotia" trawled in over two thousand six hundred fathoms, and had two six thousand fathoms lengths of cable on board (twelve tons). He also contemplated the employment of a subsidiary vessel or vessels of smaller size but good speed, of the whaler or trawler type.

13.—"Scotia" Records.

Mr. Lyon inquired as to the publication of the results of the "Scotia" expedition; and Dr. Bruce said that he is bringing out as soon as possible the Station Log of the "Scotia"—a summary of some of the data obtained at five hundred and fifty-three stations—a summary of positions, weather, sea, etc. The "Scotia" work is being published unofficially. The work of the "Challenger" expedition should be followed up south of 40° S. As a matter of fact, the Swedes and Germans have carried on some of that work in that very area instead of ourselves.

8th July, 1918.

APPENDIX III.

REPORT BY Dr. WILLIAM S. BRUCE OF A VISIT TO NORWEGIAN WHALERS IN THE MERSEY DURING SEPTEMBER, 1918.

By the kindness of Mr. Theodore E. Salvesen, of Leith, and Mr. Maguire, of Messrs. Vogt & Maguire, of Liverpool, I have had communications with four masters and a chief officer of five vessels of the Norwegian Whaling Fleet, now in the Mersey, besides with one of Messrs. Salvesen's masters in Leith. The following were the Norwegian vessels:—

1. s.s. "Orn II.," 2,757 tons net register, Captain Larsen.
2. s.s. "Thor I.," 2,655 tons net register, Captain Berggreen.
3. s.s. "Svend Foyn I., 2,416 tons net register, Captain Anderson.
4. s.s. "Bombay," 2,040 tons net register, Mr. Olsen (first mate).
5. s.s. "Solstreif," 3,409 tons net register, Captain Thorstensen.
6. s.s. "Perth," 2,245 tons net register, Captain Hansen.

Captain Hansen had left for Norway as well as Captain Johannessen, of the "Bombay," before I reached Liverpool. The five first-named steamers are all floating factories, and were engaged in whaling operations in the South Shetlands and Graham Land during the season 1917-18. The s.s. "Perth" has now no plant for the reduction of whale carcasses into oil, and was employed as a transport steamer between United Kingdom and South Georgia in connexion with the Ocean Whaling Company of Larvick.

Of these six vessels five were lying at the West Float Docks, Birkenhead, while the "Solstreif" was dry-docked at Langton Dry Dock, Liverpool, for repairs after grounding.

There was some little difficulty in getting all the masters interviewed, because they were specially occupied discharging their cargoes, but between Wednesday and Saturday I succeeded in interviewing Captains Larsen, Berggreen, Thorstensen, and Mr. Olsen at the Liverpool Public Libraries, where a special room had been lent to me by the courtesy of the Chief Librarian, Mr. George T. Shaw.

I also visited four of the vessels, viz.: "Thor I.," "Bombay," "Svend Foyn I.," "Solstreif."

It was unfortunate that Captain Johannessen had just left Birkenhead for Norway the day before my arrival, because it is he, according to the reports of his first officer, Mr. Olsen, and the other masters, who is the only one of these masters who appears to have constructed a new charting of the South Shetlands and Belgica Strait region. Mr. Olsen, first mate, had no authority from Captain Johannessen to show me his chart, which he told me was locked up on board the "Bombay," but Mr. Olsen informed me that special attention was required in surveying for Parry (Nelson) Strait, Deception Island, the Belgica Strait, which appear to be the specially active grounds of the Graham Land and South Shetlands whaling fleet.

This tallies with a similar statement made to me by Captain Skontorp, master of one of Messrs. Salvesen's vessels, the "Neko" (2,176 tons net register), whom, with the courtesy of Mr. Theodore E. Salvesen, I have interviewed in his office in Leith.

It was extremely unfortunate that none of the masters or Mr. Olsen were able to show me any alterations in black and white on Admiralty chart 3205 now proposed. But one and all quite agreed that the proposed new chart was a considerable improvement on the present edition.

It appears to me to be important, if it is possible, to secure a copy of the alterations said to have been made by Captain Johannessen, of the "Bombay," especially as he and Mr. Olsen appear to have been whaling in those waters during a period of about eight years.

This is not the same chart known to the Admiralty, viz., H. 6789/1917. But all those interviewed emphasize some similar features. Notably, an increased length north and south of Trinity Island, the proximity of Tower Hill to the northern coast, the existence of Mikkelsen Harbour, the numerous bays and coves around its coast, and the existence of many rocks above and below water. The shifting of Kendal rocks further south-east, and the incorrect charting of Austin rocks, etc.

The general results of my interview were :—

1. That the whales appear to be as numerous now as they have been at any time, with the exception of the humpback whale, which appears to have suffered, owing to its habit of hugging the coast, not only in those regions but in other parts of the world, e.g., Western Australia, etc. Humpbacks are said by the whalers to be the whales that have barnacles, and that consequently they rubbed on the rocks, close to the shore on the coast of Western Australia and West Africa, but that now they are only seen ten to twenty miles or more off the coast. It is, therefore, to be feared that the existence of this species may be threatened.

2. Whales appear to be plentiful in Bransfield Strait and all along the northern coast of Louis Philippe peninsula, Trinity and Danco coasts. They are also taken to the south-east of Bismarck Strait, 65° S. Whales have been hunted as far south as Cape Bellue and Kerlu Bay, almost 67° S. Here Gunner Anderson fastened fin whales, humpback whales, and blue whales, while Captains Berggreen and Thorstensen have hunted north-east of Pitt Island, 65° 20′ S., 65° 35′ W. They do not hunt whales in Erebus and Terror Gulf, but reckon that they catch these whales after they come through Antarctic Sound into Bransfield Strait.

3. The number of whales appears to vary with the amount of ice each season, absence of ice corresponding with absence of whales, and *vice versa*.

4. North-east of Pitt Island there were no whales in 1918, but some years previously they were taken plentifully here for the furthest south factories in Port Lockroy, Weincke Island.

5. During 1913-14 whales were scarce, and there was little ice, during 1914-15 whales were numerous, and there was plenty of ice, as also during the season 1915-16. In 1916-17 there were many whales fastened (ice conditions favourable). From February to April, 1918, whales were scarce again, and there was little ice in 1913-14.

During the first part of the season 1917-18, say, November and December, 1917, ice conditions are unknown, as the whalers did not commence to arrive on the grounds before January, 1918, but are believed to have been favourable.

There were few whales in February, 1914, and in February, 1918, and this year none of the ships are full, but this all commenced very late.

6. Up to 15th April, 1918, Captain Larsen, "Orn II.," took 8,400 barrels; Captain Berggreen, "Thor I.," took 19,700 barrels, but was on the ground earlier; Captain Thorstensen, "Solstreif"—who was later on the ground than calculated owing to an accident—took 15,000 barrels.

7. Whalers should be on the ground towards the end of November, and not later than the 15th of December. October is too early, as the whaling grounds are inaccessible owing to ice. Whalers must leave before the 15th April, for insurance and ice conditions, and, again, there is no fresh water, and the weather is bad. Whales were very scarce in February-April, 1918, at Deception Island, and all over the South Shetland group, and there was little ice and food. An *absence of ice*, even in the far south, *means less whales*.

8. In 1915-16 there were ten floating factories and thirty-one whale catchers, and during 1917-18 there were five floating factories and sixteen whaling boats.

9. There are fewer floating factories at present owing to the open freight market offering much more lucrative employment. Factory ships have been extensively used to carry burning oil to France and Britain from the United States, etc.

The following is a list given to me as destroyed :—

"Hectoria,"	Torpedoed.	"Roald Amundsen," mined.
"Hvalen,"		"Guvernören," burnt at South Shetland.
"Benguela,"		"Horatio," burnt at South Shetland.
"Capella,"		"Restitution," lost near the Bristol Channel.
"Falkland,"		
"Normanna,"		

10. Humpbacks calve off the coast from South Africa to Fernando, as well as sperm and sei whales. (Captain Larsen had seen only three sperm whales at South Shetlands, and these were not very large.)

11. The whalers told me that *no fur seals* were known, either in the South Shetlands or in South Georgia.

They reported a few sea-elephants in the South Shetlands, and plenty of Weddell seals and sea-leopards.

12. Besides factory steamers there are pure carrying steamers, that carry oil from the shore stations mostly in barrels. Factory steamers are so called because the oil is boiled on board. They are of large size, and their usual speed is about nine knots, and they return home with the oil. Hunters go at about twelve knots and winter at Monte Video and Buenos Aires. The factory steamers carry home about four to five thousand tons of oil. Each factory steamer has about twenty-four boilers of considerable size on board.

13. The whalers' passage is from the Falkland Islands towards King George and Nelson Islands. Here three prominent hills, which are free from snow in the early part of the season, are sighted if possible, two in King George Island, and one in Nelson Island. They enter by Parry (Nelson) Strait into Bransfield Strait and thence towards Belgica Strait. Captain Skontorp emphasized the importance of Parry (Nelson) Strait to get into the belt of open water, lying north of Bransfield Strait ice, the northern edge of which usually lies between Martin's Head and Deception Island, in which case Admiralty Bay is used as an anchorage, but should the open water not extend east of Telefon Rocks, so that Admiralty Bay is closed with ice, the whalers then make for Deception Island.

The five whalers I met in Liverpool, however, told me that Admiralty Bay was not used much now, and then laid stress on the importance of Port Foster.

Factory ships anchor in Port Foster, and the uncharted harbour, called Mikkelsen Harbour, on the south side of Trinity Island, but there are several other anchorages and harbours for factory steamers in Belgica Strait.

14. It may be useful to mention that the general current in Belgica Strait appears to run to the north-east, and that the ice from Belgica Strait drifts on through Orleans Channel, where many large bergs are stranded, which are troublesome for the Mikkelsen Harbour anchorage. But in 1910, when there was little ice, there were five large factory ships lying in Mikkelsen Harbour. But usually there is too much ice for convenience. Captain Larsen, in the "Bombay" and "Orn II.," has lain in Mikkelsen Harbour every year, 1910-17, sometimes for six weeks, and even longer on occasions. The anchorage is in forty-five to eighty-six feet, but it is not a safe harbour, for one must always be on the look out for icebergs, and there is a swell with the south-west wind.

Besides the above I have made a considerable number of other notes regarding differences which the whalers recognize between the proposed new Admiralty chart 3205, and what they personally know of the coast line, both of South Shetlands and Graham Land, but more particularly in Graham Land. It appears to me to be rather beyond the scope of this report to include these remarks here, so I propose merely to incorporate them in proof suggestions for the future "Sailing Directions" of the region that I am at present working at, under the direction of Captain Smith. When the proofs of these appear, the Hydrographer may possibly allow the "Falkland Islands Dependencies Committee" to see them if necessary and if desired. I have, however, no chart plans whatever from any of the whalers I have interviewed in Leith, Liverpool, or Birkenhead.

The above Mersey-Norwegian factory whalers strongly recommend me to get in touch with the skippers of the small hunting vessels, which they emphasized went into holes and corners, impossible for the large factory ships to go into, as is well known, right from Antarctic Sound, latitude 63° 20′ S., longitude 56° 30′ W., to Cape Bellue, latitude 66° 32′ S., longitude 66° 30′ W.

While this might be profitable, yet I am almost positive that these extraordinarily good seamen have done almost every part of their coastal research almost entirely without any instruments whatever, and that they will not have any black and white cartographical records.

But it occurs to me more particularly than before, that if the serious cartography of this region is to be undertaken that these hunting men, together with their small fast steamers, should be used for their particularly accurate knowledge of the coast, in addition to a larger scientific ship already suggested.

May I suggest that this might be further improved upon by the utilization of several small swift motor-craft, such as will probably be available after the War. I would also suggest that, while recognizing the importance of the whales and seals themselves, and the importance of the meteorological, mineralogical, and biological research, the work to have the first place is the cartography and sailing directions, as I stated in my communication to the Committee, of the 14th May, 1918*.

I was particularly impressed by this when on board the the s.s. "Solstreif," in the Liverpool Langton dry dock, where she was being repaired on account of going ashore on a rock near Cape Melville, 61° 55′ S. latitude, 57° 26′ longitude.

The "Ornen" was nearly on the inner rocks on which the "Solstreif" was wrecked, and the "Telefon" was totally abandoned on the rocks guarding the south-west entrance to Admiralty Bay in 1908.

Captains Berggreen and Thorstensen walked from Whaler's Bay to Pendulum Cove and describe much red lava lying along this route, and many hot springs to the south of Pendulum Cove. There is also a quantity of brown and black lava near Neptune's Bellows.

They report that the factory steamer "Gubernador Boris" lay in Pendulum Cove, seven or eight years ago. They describe a supposed copper mountain near Borgen Bay and Neumayor Channel, notable on account of its green colour, but apparently rather inaccessible owing to a glacier. From the Falkland Islands the whalers usually steer for Parry (Nelson) Strait, endeavouring to sight three remarkable mountains, two in King George Island and one in Nelson Island, which are distinct, because they are bare when the rest of the land is mostly ice covered. Captain Berggreen has given me samples of rocks from Deception Island, which are now being examined by the Geological Survey for Scotland, the report of which has been delaved owing to scarcity of assistants. He stated, however, that they have not found silver in Parry (Nelson) Strait.

The following is the translation of a bad copy of a document by Dr. Charcot. The original was found by Captain John E. Berggreen on the west side of Pendulum Cove in 1918 and handed over to Mr. A. G. Bennett, the Government officer there. I have to thank Mr. Ch. le Harival, Heriot Watt College, for this reconstructed translation.

"*Notice to Navigators.*

"I think I ought to warn all navigators who may go to Wandel with the intention of staying at Port Charcot, that a ship is far from being in safety there during the north-east winds, which are by far the most prevalent and the most violent in this region. During these north-east winds the swell is strongly felt, and ice-blocks of large size make their way into the bay (?) and may occasion serious damage. A chain stretched across the entrance of the bay (?) and securely fastened at both ends may protect to a certain extent the ship from the ice blocks, but hawsers, even of steel wire, are soon cut. In 1904-1905 the 'Français' was able to hold out nine months, because the ice, very abundant and driven by the wind, generally came drifting (?) against the chain, thus forming a very effective barrier against the swell and floating ice. As soon as the north-east wind ceases the ice drifts away. In January, 1909, when the ice was rare, the 'Pourquoi Pas' was in a dangerous position, and could not have stayed there during the winter.

"The only shelters in the vicinity are Port Lockroy in the island of Wiencke, and Port Circumcision in the island of Lund-Petermann. The latter port is excellent, after having avoided the rocks which make the entrance rather difficult. However, the swell is also felt there and ice-blocks enter; a strong barrier must be made at the entrance, and the ship must be securely moored.

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* Appendix I.

"To reach it from Wandel one must pass through Lemaire's Channel. A temporary shelter from the north-east winds can be found opposite Hovgard, but steam must be kept up. There is no anchorage in all these parts, and the icebergs drift backwards and forwards in a dangerous manner. In calm weather the current sets always towards the north.

"(Signed) J. CHARCOT."

"*Notice to Explorers and Whalers.*

"If the Government of the Argentine Republic should carry out their intention of establishing an observation station *on land* in these regions, I think it would be advantageous to do so at Wandel Island, which is *generally* more accessible, and which is, in my opinion, more suitable for observation purposes. On the other hand, a ship ought rather to endeavour to winter at Lund Island.

"Wandel can only be reached in calm weather with winds from a southerly direction, as the ice, brought by the north-east wind, disappears as soon as it ceases. One may wait for favourable weather at Port Circumcision in Lund Island, or, better still, at Pork Lockroy in Wiencke Island. I would advise the ship entrusted with the establishment of a shore station to remain under steam in the large north bay at Wandel, and if she enters Port Charcot to anchor securely, ready to get under weigh at the slightest sign of north-east winds, and if she is obliged to stay there, to stretch a strong chain across the entrance. A ship *under steam* can find a temporary shelter against north-east winds in Lemaire's Channel opposite Hovgard, but the drifting icebergs are dangerous. I do not recommend Saltpetre Bay (baie de la Salpétrière), where icebergs are extremely numerous. The frequent and violent north-east winds are *generally* heralded by a falling barometer, dull weather in the Straits of Gerlache, and a rise in temperature. They are generally accompanied by snow, drift snow (?) and thick weather, and may blow with great violence even in summer. Their duration varies from five or six hours to several days. They *generally* cease when the glass begins to rise, the thermometer to fall, and Wiencke Island to appear; but they may rise again very suddenly.

"Whalers and sealers will find nothing to do in these parts.

"(Signed) J. CHARCOT."

APPENDIX IV.

MEMORANDUM OF INTERVIEW WITH DR. R. N. RUDMOSE BROWN.

THE following is a synopsis of the matters to which Dr. Brown invited the attention of the Committee:—

1. Surveys most needed in the interests of whaling and possible sealing.
2. Hydrographical surveys required.
3. Geological explorations in view of possible minerals.
4. Possibility of establishing fox farms: the danger to the existence of penguins.
5. Preservation of sea-elephants in view of excessive hunting of animals so easily captured.
6. Investigation of plankton of the Southern seas as throwing light on whale migrations.

In reply to an inquiry by the Chairman as to his experience of the regions in question Dr. Brown explained that he accompanied the Scottish National Antarctic Expedition (1902-4) in the capacity of naturalist. He had stayed for eight months in the South Orkneys while the "Scotia" was wintering there, and had been in the vicinity of the South Sandwich Islands, but had not visited South Georgia.

1.—SURVEY.

Detailed survey is required in all the Dependencies, but there is no need to dwell on this since it must surely be included in any scheme of exploration and development. Certain coasts, however, may have more practical importance than others, e.g., the eastern part of the south coast of South Georgia and the South Sandwich group. The importance of the survey of these coasts lies in the possibility of extending whaling into the more open waters of the eastern part of the Weddell Sea and the waters around the South Sandwich group. The

prospect of finding good harbours in the South Sandwich group is small, and the weather conditions, with incessant strong winds and fogs, are adverse, but they make the necessity for good surveys all the greater.

2.—Hydrographical Survey.

The hydrographical survey would of course entail the exploration of all the shallow water on the Sandwich-Orkney ridge—an important matter in view of the possibility, even if a remote one, of rocks comparable with the lately discovered Undine Rock, or the Shag Rocks.

3.—Geology.

The geology of the Dependencies is not well explored, but enough is known to make the discovery of valuable mineral deposits most improbable. The South Shetlands need more investigation in view of the reported existence of coal. South Georgia might profitably be explored, but the South Orkneys, the South Sandwich group, and most of Graham Land are fairly hopeless from an economic standpoint. However, on the east of Graham Land the Swedes found formations which may be of Jurassic or of Permo-Carboniferous age. In either case they might contain coal—probably not of a high order—but valuable as being the only coal in that part of the world. Mining would present certain inconveniences, but such have been overcome in Spitsbergen and could be overcome in Graham Land. Export would be more difficult, but it is premature to consider such questions—when the coal has not been discovered.

In reply to an inquiry, Dr. Brown added that he considered the possibilities to be sufficiently good to make it desirable that a geologist should accompany the expedition.

4.—Fox Farms.

The question of fox farms is a highly problematical one. In the first place such a scheme would be possible only in South Georgia. The other Dependencies have not the conditions necessary, climatic or otherwise, and even South Georgia might prove to be too wet, and not cold enough in winter, for the winter furs to obtain a condition which would fetch a high price. The fox would be the Arctic fox—blue variety. The winter hide of this fox is very valuable, and has been steadily rising in price for the last twenty years. It is regarded by the Spitsbergen hunters as one of the most valuable furs, but the animal is now becoming rare in that locality. It is, however, found in Siberia, where it is impossible to hunt it so intensively as in Spitsbergen. Of course foxes and penguins could not live side by side. The penguins would need to be sacrificed in part or the whole of the island. The economic objections are two: *firstly*, the spread of foxes might injure any fur seal rookeries established on the coast; *secondly*, the disturbance of the balance of life might, in ways not obvious, react on the whale fisheries. The problem, therefore, would need to be most carefully weighed, and a decision could not be reached without further study on the spot of the life habits of the animals of South Georgia and surrounding seas. In Labrador a fox farm was started in 1905, and the scheme was revised and extended in 1912.

5.—Rats.

A further matter to be considered is the spread of rats in South Georgia. This may also affect seal rookeries and will certainly have an ill effect on the penguins.

6.—Preservation of the Sea-elephant.

Dr. Brown called attention to the danger of the sea-elephant being exterminated, despite restrictions imposed in the licences granted for hunting them, since it is doubtful whether these restrictions will mean much if the sea-elephant becomes scarce. The animal is very defenceless on the beach and easily killed.

7.—Plankton.

The exploration of the plankton of the southern seas is a subject that has been little pursued so far. The only detailed collections and observations are those taken in the "Scotia" in 1903-4. The results, which are now in Paris, are nearly ready for publication, but this may be still further delayed.

The importance of plankton investigations lies in the relation between plankton and whale migrations. Plankton includes the food of all whales, except perhaps some of the finners (*seihval*), the sperm whales, and the killer (*grampus*). But the species which do not feed on plankton find other food among animals ultimately

dependent on plankton for much of their nutriment. Therefore the key of the problem of whale migrations lies in the distribution of plankton.

Leaving out of account ice-frequented seas in the far south, attention may be confined to seas in which whaling is profitable. The chief characteristic of the plankton in these seas is the abundance of plant life (diatoms, Peridiniæ, etc.), and the scarcity of animal plankton (Euphausiæ, pteropods, etc.). Euphausiæ, it is true, are not infrequently found locally in large numbers—generally noticeable through the presence of many Cape pigeons and other birds—but their scarcity in ice-free waters is characteristic. Among the pack they seem more plentiful. These crustacea in their home are dependent on phytoplankton, which is extraordinarily abundant in certain places and at certain times—but comparatively scarce elsewhere and at other times. Such problems require investigation. The migrations of plankton—with little power of free movement—are related to currents and light. Much phytoplankton is said to go north in winter towards the light. That is a plausible suggestion, as diatoms at least cannot flourish in darkness. On the other hand, much is certainly frozen into the pack and remains alive; and the suggestion of free migrations on the part of diatoms is difficult to admit. A research vessel should make collections of plankton day and night. The work that has been done in this connexion is but a beginning. The research ship would presumably be supplied with the necessary plankton nets. Observations would be required of the physical condition of the plankton at the time of each catch, and the determination of all the species present would be very desirable. Useful results would, however, be obtainable from a volumetric estimation of the total food-content of the water, supplemented by the determination of the dominant species. As regards nets, Dr. Brown said that a full-speed tow-net had been constructed on the "Scotia" and had been used with satisfactory results, even at a speed of ten knots. It was not possible, however, to obtain the larger varieties with that net, and, of course, a representative catch is not possible if the vessel is proceeding at too high a speed.

8.—Research Ship.

8. As regards Dr. Bruce's suggestion of a vessel of 1,200 to 1,500 tons, Dr. Brown said that the matter was of course one for professional sailors to decide; but that, in his opinion, a ship of about 600 tons, being much handier to manœuvre, would be more suitable for work among ice and on badly charted coasts.

APPENDIX V.

THE WHALING INDUSTRY OF THE DEPENDENCIES OF THE FALKLAND ISLANDS.

PART I.

1.—Rise of the Industry.

The occurrence of whales off South Georgia was first reported by Captain Cook, who sighted and took possession of the island in 1775. Captain James Colnet sailed north-west of South Georgia in 1793-4, and confirmed Cook's report of the enormous number of whales, especially black whales. Captain Bellingshausen visited South Georgia in 1819, and met British whalers there. Captain William Smith discovered the South Shetlands in 1819, and reported whales there also. Ross especially noted the presence of whales in Erebus and Terror Gulf, which, fifty years later (in 1892), led to the despatch to the gulf of four vessels of the Dundee whaling fleet. A Norwegian expedition in charge of Captain C. A. Larsen also left the gulf about the same time. The whaling enterprise was a failure, as the vessels were equipped for bowhead whales, and had not the modern guns and gear required for dealing with finner and other whales.

On the return of the Dundee expedition to the United Kingdom an effort was made, privately, but without success, to arouse interest with a view to the introduction in Antarctic waters of the Norwegian type of whaling—then unknown in Britain. Later, Captain Larsen was chosen by Dr. Nordenskjöld as master of the "Antarctic." This vessel was wrecked, all hands being rescued by the Argentine sloop "Uruguay"; and one consequence of the interest thus aroused in Buenos Aires was the formation of an Argentine company (the Cia Argentina de Pesca) to carry on whaling at South Georgia. This company began operations in December, 1904.

and was granted a lease as from the 1st January, 1906. Steam whaling around the Falkland Islands and the South Shetlands was started by Mr. Alexander Lange in the season 1905-6.

2.—Extent of the Industry.

The principal whaling fields are the two dependencies of South Georgia, and the South Shetlands with Graham Land. Whaling has also been carried on to a much smaller extent in the South Orkneys, and apparently on one occasion at the South Sandwich Islands. A magistrate is stationed at South Georgia, where there is a permanent whaling settlement, and operations continue all the year round; in the case of the other Dependencies a representative of the Colonial Government accompanies one of the expeditions. Eight leases of land sites for whaling purposes have been granted for South Georgia. In the South Shetlands one lease has been granted on similar terms to those of the South Georgia leases, but the industry in the Dependencies other than South Georgia is almost entirely conducted by a system of annual licences authorising the employment of not more than two floating factories and two or three steam whalers. In practice more than one floating factory has seldom been employed under one licence. At one time it was the practice to issue licences covering all the Dependencies except South Georgia; but, in 1912, it was decided :—

(1) That separate licences should be issued for :

(*a*) The South Shetlands and Graham Land;

(*b*) The South Orkneys;

(*c*) The South Sandwich Islands; and

(2) That the number of licences issued in any one year for the South Shetlands with Graham Land should not exceed ten, and that not more than seven licences should be issued annually for either the South Orkneys or the South Sandwich Islands. Later, it was decided that after the 1st October, 1914, no further licences or leases for whaling purposes in the Dependencies, other than South Georgia, should be issued, with the exception of renewals of existing licences.

As regards the vessels employed, the following table shows the number to which the companies were entitled, at the opening of the 1914-15 season, by their respective leases or licences :—

	Floating factories.	*Whalers.*
South Georgia, in addition to land stations ...	8*	21
South Shetlands and Graham Land, in addition to one land station	12	32
South Orkneys	4	9
South Sandwich Islands	0	0
	24	62

(* Eight permissible, but only two actually used.)

The full number of whalers authorized for the highly profitable whaling fields of South Georgia and the South Shetlands with Graham Land were always employed before the War, but this was not the case as regards the South Orkneys and the South Sandwich Islands. During the War there has been a considerable reduction in the pursuit of whales almost all over the world, except in South Georgia, where, in consequence of the demand for oil, it has been necessary to permit the temporary employment of additional extra whale catchers. The number of whale catchers operating in the South Shetlands is less than half of what it was previously, and whaling in the South Orkneys has entirely ceased. This has been due partially to the demand for tonnage for other purposes and to losses sustained by the whaling fleet from enemy action and other causes.

The labour engaged in the industry is almost entirely Norwegian. Since the invention of the harpoon gun by Svend Foyn, in 1865, a large and highly skilled whaling population has grown up in Norway. While the transport vessels can be manned by British crews, the skilled ratings on the whale catchers and floating factories, and at the land stations, can only be filled with Norwegians, and, although persons of other nationalities are sometimes employed in unskilled ratings, British subjects are apt to object to the Norwegian food. The British whaling population which formerly existed seems to have disappeared entirely.

Great skill is required in some of the ratings, particularly that of gunner. The training of a new man as a gunner always involves some loss of whales. Consequently only men of considerable whaling experience are tried in this capacity.

The number of men employed at South Georgia in the season 1917-18 was 1,800, not including the crews of transport vessels.

The following table,* extracted from the report on the 1915-16 season at the South Shetlands, is of interest as showing the rate of wages then paid to the workmen in the whaling industry :—

Occupation.	Wages per month.	Share (Oil) per barrel.
On Floating Factories—		
Engineers	from 120 to 200 kroner	from 4 to 10 öre.
Mechanics	,, 40 ,, 120 ,,	,, 3 ,, 5 ,,
Carpenters	,, 80 ,, 100 ,,	,, 4 ,, 5 ,,
Blubber Boilers	,, 60 ,, 70 ,,	,, 3 ,, 5 ,,
Flensers	,, 55 ,, 70 ,,	,, 3 ,, 5 ,,
Ordinary Labourers	,, 40 ,, 50 ,,	,, 1 ,, 3 ,,
Stewards	,, 100 ,, 110 ,,	,, 6 ,, 8 ,,
Cooks	,, 70 ,, 90 ,,	,, 3 ,, 5 ,,
Firemen	,, 40 ,, 55 ,,	2 ,,
Sailors	50 ,,	2 ,,
Boys	,, 20 ,, 30 ,,	,, ,, 1 ,,
Purser	,, 80 ,, 120 ,,	,, ,, 6 ,,

Occupation.	Wages per month.	Share per whale.			
		Blue.	Fin.	Humpback.	Right
On Whale Boats—					
Gunner	125 kroner	80 kroner	50 kroner	30 kroner	200 kroner
Masters (when not Gunner)	100 ,,	6 ,,	5 ,,	4 ,,	10 ,,
Engineers (1st)	160 ,,	6 ,,	5 ,,	4 ,,	10 ,,
,, (2nd)	130 ,,	6 ,,	5 ,,	4 ,,	10 ,,
Firemen	40 ,,	4 ,,	3 ,,	2 ,,	10 ,,
Sailors	60 ,,	6 ,,	5 ,,	4 ,,	10 ,,
Stewards	75 ,,	6 ,,	5 ,,	4 ,,	10 ,,

(1 krone equals about 1s. 1½d. 100 öre equals 1 krone.)

As regards the several Dependencies :—

A.—South Georgia.—The first factory in South Georgia was built by the Cia Argentina de Pesca, an Argentine company, which was granted a lease of a site at Grytviken for a period of twenty-one years from the 1st January, 1906. Subsequently seven other leases of land sites for whaling purposes were granted for a similar term—three dating from 1908, three from 1909, and one from 1911. Particulars of all the above leases will be found in Annexure I. (page 58). Of the existing companies four are Norwegian, three British, and one Argentine. In considering the annual returns relating to the industry, it must be remembered that the figures for the South Georgia Company include those for the closely allied firm of Messrs. Chr. Salvesen & Company. These firms hold a lease each, but work in common.

Each lease carries the right to employ one floating factory and two steam whalers, except that the oldest lease allows four steam whalers. Three companies are allowed an extra steam whaler each, under licence. The total number is thus twenty-one. The later leases contained the obligation to utilise the whole carcass of the whale, and permitted the use of only two whalers.

B.—South Shetlands and Graham Land.—A lease at Deception Island for a period of twenty-one years from the 1st October, 1912, is held by the Hektor Whaling Company, Norway, which also holds a licence. A list of the licences issued for the 1914-15 season, i.e., the first season following the outbreak of the War, will be found in Annexure II.

It will be seen that one licence was held by a British company and eight by Norwegian companies; the tenth licence being held by a Chilian company. The season in the South Shetlands lasts from November to March.

C.—South Orkneys.—No whaling has been carried on at the South Orkneys since the season 1914-15. Annexure II. includes a list of the licences, four in number, issued for that season, all of which were held by Norwegian companies. Only one of the licences was actually worked.

* Tables showing the rates paid at South Georgia and the South Shetlands in more recent years will be found in Appendix XI. See pages 92 and 93

Whales are usually plentiful at the South Orkneys, but the short season, lack of safe harbours, and bad weather combined, form a serious disadvantage. It has been stated that in the most open seasons the factories may be able to remain in the roadstead fourteen weeks, but that a stay of twelve weeks is more likely to be the real length of the season.

D.—South Sandwich Islands.—No licences have been granted since the 1912-13 season, when (*vide* Annexure II.) six licences were issued, all to Norwegian interests. None of these licences was actually worked. The only record of whaling in these waters, and that a very scanty one, is for the season 1911-12, when one company conducted operations. Whaling in this group is attended with great difficulty, as no satisfactory harbour is known in the group, which consists of a chain of volcanic islands, in some of which the volcanoes are still active. In many cases the constant emission of poisonous fumes makes it difficult to land, and no attempt has been made to establish a shore station.

3.—Regulation of the Industry.

(*a*) *Legislation*: The whale fishery was first dealt with by law by Ordinance No. 3 of 1906, which made it unlawful to take whales without a licence, and imposed royalties on each whale caught, at the following rates, viz.: right whale, £10; sperm whale, 10s.; other whale, 5s. This system was, however, considered unsuitable. The Ordinance was therefore repealed, and the whale industry is now regulated by Ordinance No. 5 of 1908 (the principal Ordinance) and amending Ordinances, and by separate regulations for South Georgia and the other Dependencies, made under the principal Ordinance. A summary of Ordinance No. 5 of 1908, as amended, will be found in Annexure III., which also includes summaries of the regulations and of the forms of lease and licence. It may be added that the Ordinances of the Legislature of the Falkland Islands do not necessarily apply to the Dependencies, but can be extended to them by the Governor in Council, under section 3 of Ordinance 9 of 1908.

(*b*) *Policy*: The present policy aims at:—

(1) Limiting the extent to which the pursuit of whales may be carried on;

(2) Reducing the amount of waste involved to the narrowest limits consistent with existing rights and with not involving the companies in work entailing an actual loss.

To secure the first of these objects it was decided (as already stated) to issue no further leases or licences, other than renewals of annual licences already granted, and to allow no further addition to the number of vessels authorized to catch whales. No attempt has been made to regulate the number of whales taken in any one season; but the killing or shooting of any whale calf, or any female whale which is accompanied by a calf, is prohibited. The scope of this prohibition is, however, in practice, restricted to such calves as are in company with their mothers, and it does not afford any protection to immature whales not falling within this category.

The grant of permission to operate additional floating factories was at one time thought likely to result in an increased slaughter of whales, but further experience led to the conclusion that it was practically impossible for the steam whalers already licensed to increase their catch of whales, and the policy of the Government was revised in consequence. In the Dependencies other than South Georgia the use of second floating factories is now permitted, conditions being imposed to secure adequate equipment for operating with a minimum of waste. The factory or factories are compelled to carry pressure boilers 10 feet long and 7 feet in diameter, or with an equivalent cubic capacity; but it has not been thought expedient to compel them to carry plant for making guano, since it is doubtful whether, even in peace time, the manufacture of guano on board ship can be made profitable. Licensees, if using not more than two steam-whalers, are required to carry on their floating factory or factories a total of not less than nine pressure boilers of the prescribed capacity; if a third whaler is used twelve pressure boilers must be installed. With regard to South Georgia, those companies whose leases did not bind them to utilize the whole carcass have been encouraged to erect shore stations for the purpose.

In consequence of the War it has, unfortunately, been necessary to relax the regulations for the prevention of waste of the less valuable portions of the whales, and also those in regard to the towing and buoying of carcasses. In addition to allowing, as already stated, the temporary employment of additional whale catchers at South Georgia, it has been necessary to incur certain conditional obligations as regards the grant of additional whaling facilities after the War.

4.—Production of the Industry.

(*a*) *Catch*: The seasonal reports from the Dependencies are summarised in Part II. of this memorandum. A table of the catch, showing also the number of steam whalers employed, will be found in Annexure IV. More detailed figures in regard to South Georgia are given in Annexure V. The tables show that formerly the catch at South Georgia mainly comprised humpback whales, but that latterly the blue and fin whales have predominated. Some right whales are still being taken, although the number has fallen off considerably. A fair number of sperm whales was taken in 1913-14 and 1916-17. The only records of the sei whale are in 1913-14 and 1917-18, ninety-four being taken at South Georgia in the earlier year and forty-nine in the later. There are occasional records of the capture of bottlenose whales. The most remarkable feature in the table is the practically continuous decline since 1911-12 in the take of humpbacks, although a considerable number of this species was taken in 1915-16. The higher take of the blue and fin whales is attributable to the use of larger catchers and stronger tackle, and to the higher reward now offered by the companies for these animals. In this latter connexion reference may be made to the rates of reward in the tables on pages 49, 92, and 93. The reason for the decline in the take of humpbacks is not so clear. In 1912-13 it was reported to be due to scarcity, which may have been caused by excessive hunting in the past, whether at South Georgia or elsewhere; on the other hand, there is evidence that, in subsequent years, the take has not been commensurate with the number of whales observed, since the catchers were more intent on the pursuit of the larger whales. In this connexion the reports of the Magistrate for the years 1913-14 and 1914-15 (see Part II. of this memorandum) are of particular interest. The statistics for the South Shetlands present somewhat similar features to those for South Georgia; but, in the case of the former Dependency the take of humpbacks never predominated to the same extent as at South Georgia. At the South Orkneys the larger whales have been the more plentiful. As regards the South Sandwich Islands there is only one record—that for 1911-12—when four blue, eleven fin, and thirteen humpback whales were taken.

(*b*) *Products*:* Whale oil is classified into five grades, numbers 0, 1, 2, 3, and 4. Numbers 0 and 1 are made entirely from blubber; number 2 from the tongues and kidney fat and from the residue of the blubber boilings; number 3 from the flesh and bones; and number 4 from refuse. The oil is usually classified for sale upon the basis that the various qualities must not contain more than the percentages of impurity specified in the following table:—

	Fatty acid.	*Water and dirt.*
No. 0 and No. 1	2	$\frac{1}{2}$
No. 2	6	$\frac{1}{2}$
No. 3	15	1
No. 4	30	1

Three products can be obtained from the dried meat and bones: (*a*) whale meat meal, manufactured exclusively from absolutely fresh whale flesh; (*b*) whale guano, made from the remaining flesh and about one-third of bones; (*c*) bone meal, made exclusively from bones. The whole of the dried carcass may also be made into one produce, forming a rich guano. Whale meat meal is a cattle food containing about seventeen-and-a-half per cent. of protein. Whale guano contains about eight-and-a-half per cent. ammonia and twenty-one per cent. of tribasic phosphates of lime. Bone meal contains about four per cent. ammonia and fifty per cent. phosphates.

The value of whalebone, baleen, or finners (as the whalebone of the species of fin whales is commonly called), had so decreased before the War that it was questionable whether the expense of the marketing was not heavier than the value realized. There was no doubt that it did not pay to ship humpback finners at the prices then obtainable. At present, however, there seems to be a fair market for the whalebone of fin whales.

The table in Annexure VI. shows the quantity and value of the oil, baleen, and guano produced in the Dependencies in recent years. For the reasons already indicated, the statistics do not represent the full output of baleen or whalebone. As regards the values, it should be noted that these are the conventional customs declarations, and are usually much below the actual sale prices. For example, the value of the oil (197,213 barrels) produced at South Georgia in the half-year ending 31st

*Much of the information in this section is extracted from the Report on the Scientific Results of the Scottish National Antarctic Expedition, Volume 4, pages 475 to 486.

March, 1917, was valued by the companies at, approximately, £712,627. The oil was, however, actually sold on a scale of £50 per barrel for No. 1 oil. Taking an average of £45 for the whole production, the amount realized was probably not far short of £1,500,000. On the other hand, this represents an inflated value due to the War.

(*c*) *Utilisation of the Carcass*: The average production of oil and guano per whale serves to indicate the extent to which the carcass is being utilized; and Annexure VII. gives the figures for :

(*a*) South Georgia, from 1909-10 to 1916-17 :

(*b*) South Shetlands, from 1911-12 to 1916-17.

The table indicates a more complete utilisation of the carcass year by year up to 1914-15; but, in considering the figures for South Georgia, it is necessary to make allowance for the fact that up to 1912-13 the smaller humpback formed the greater part of the catch, whereas after that year the blue and fin whales largely predominated. In this connexion the following table of the average yield of each species of whale is of interest :—

Species of whale.	*Average yield of oil in barrels.* (6 *barrels* = 1 *ton.*)
Right	60 to 70
Blue	70 to 80
Fin	35 to 50
Sei	10 to 15
Humpback	25 to 35
Sperm	60

There is no doubt, however, that there has been an improvement in the utilisation of the carcass in late years. Considerable additions have been made to the reducing plant, and the number of open and pressure boilers in use in 1916-17 showed an increase of about twenty-five per cent. as compared with the number in 1914-15. In 1915-16 the larger species of whale were reported to be found in poor condition during the whole of the season, and the companies were hampered by lack of coal and empty barrels. The lower returns of guano in the last two years are largely attributable to the special conditions arising out of the War, which have necessitated some relaxation of the regulations in order to secure a maximum output of oil, particularly of the higher grades. As regards the much lower yield of guano in the South Shetlands as compared with South Georgia, it must be remembered that there is only one shore station in the former Dependency, and that only one of the floating factories had been provided with a guano plant. In South Georgia, on the other hand, several of the companies are in a position to manufacture guano under normal conditions. It will be noted that there was no output of guano in the South Shetlands during 1916-17. This was due to the facts that the shore station had been closed down owing to tonnage difficulties, and that the guano plant had been removed from the only floating factory so equipped. The plant was stated to be unworkable on board the ship.

5.—Revenue from the Industry.

An export duty of 3½d. per barrel of forty gallons is levied upon whale oil exported from the Falkland Islands and its Dependencies. The appended table shows the revenue of the Colonial Government, actual, or estimated, from the whaling industry, and also the total revenue of the Colony :—

Year.	1914.* (Actual.)	1915.* (Actual.)	1916. (Actual.)	1917. (Actual.)	1918. (Estimate.)	1919. (Estimate.)
Export tax on whale oil	£ 5,262	£ 5,435	£ 7,839	£ 6,465	£ 4,500	£ 3,800
Whaling leases and licences	4,400	4,700	2,300	2,200	2,200	2,200
Total	9,662	10,135	10,139	8,665	6,700	6,000
Total ordinary revenue of the Colony	33,760	34,347	39,106	36,491	30,247	35,776

* In these years the rate of duty was 3d. per barrel of forty gallons.

6.—Falkland Islands.

Although the terms of reference to the Committee do not cover the Falkland Islands themselves, a brief statement of recent whaling operations in those waters may be of interest. Towards the end of 1908 the British firm of Messrs. Salvesen & Company began the erection of a whaling factory on New Island, West Falkland, having, with the permission of the Government, obtained a site from the lessee. The factory was the first erected in the Colony, and was equipped with the most modern machinery for utilising the whole carcass of the whale. The station was completed in 1909, and the following statistics are taken from the Blue Book reports:

Season.	Number caught.	Oil.		Whalebone.		Guano.		Total Value.
		Barrels.	Value.	Tons.	Value.	Bags.	Value.	
			£		£		£	£
1912-13	200*	6,628	26,512	—	—	—	—	26,512
1913-14	300*	4,505	13,515	80	—	3,363	1,681	15,196
1914-15	200*	7,434	29,763	10	18	7,870	3,849	33,630
1915-16	69	4,902	16,340	—	—	1,014	500	16,840

* Approximate figure.

No whaling operations have been carried on since March, 1916, and the station at New Island was dismantled in October of that year and removed to South Georgia. There is no record of any other whaling at the Falkland Islands in the years mentioned.

PART II.

Summary of the Seasonal Reports from the Dependencies

1.—*South Georgia.*

Complete statistics for the early years of the whaling industry at South Georgia are not available, but the following is a summary of the reports received in respect to the years from 1909-10 and onwards.

1909-10.—Seventeen whalers were engaged, and all the companies except one continued whaling operations throughout the year.

1910-11.—The companies engaged in the whale fishery employed nineteen licensed steam whalers. Three of the companies continued operations during the winter. At the commencement of the season whales were reported to be very numerous off the north and north-east coast.

1911-12: *Summer Season.*—Twenty-one licensed steam whalers, two of which arrived late, were employed during this season, a most excellent one, the results of which exceeded those of the previous record season, 1910-11. The largest number of whales was caught during the months of November, December, and January; the continual stormy weather during February and March often made hunting quite an impossibility. There was a considerable increase in all the species of whales killed, with the exception of the humpback, which showed a slight decrease.

Winter Season.—Only three companies continued whaling operations throughout the whole of the winter months, during which eight hundred and fifty-four whales were taken, a decrease of one hundred and fifty-six as compared with the previous year. The weather conditions had much to do with this difference.

1912-13: *Summer Season.*—Twenty-one steam whalers were employed, two of which did not commence operations until the beginning of January. The season, while on the whole very successful, showed a decrease of one thousand four hundred and eighty-four whales, as compared with the previous season. This was accounted for by the scarcity of humpbacks, only two thousand two hundred and fifty-one of these animals being taken, as compared with five thousand one hundred in the half-year ending the 31st March, 1912. More whales were caught from October to December, 1912, than during the latter half of the season 1912-13.

Winter Season.—Four companies continued whaling operations during the winter months, but from the end of June to August little hunting was done. Six hundred and fifty-three whales were taken, a decrease of two hundred and one as compared with the corresponding period of 1911-12.

1913-14: *Summer Season.*—The companies engaged employed in all twenty-one licensed steam whalers. Owing to the great and continued scarcity of the humpback, the season could not be regarded as a successful one, when compared with former seasons, but, fortunately, large blue and fin whales were numerous, and are to be found off the Dependency practically the whole year round. As regards the humpback, the following extract from the Magistrate's report is of interest:—

> "The question has often been debated by the local whalemen as to the real cause of this continual scarcity of the humpback whale. Is it the continual killing that has thinned them down and frightened the remainder off; or in the course of their ocean migration have they merely changed their course for the time being, to come back again? The general feeling is hopeful, and inclined to take the latter view, although it is really hard to say. On more than one occasion shipmasters have reported to me schools of humpbacks three hundred or four hundred miles off the land. A very reasonable contention is also held that the humpback whale, while foraging along his usual ocean track finds plenty of food all the way; this will delay, if not altogether prevent, him from touching at his usual resorts in these latitudes."

During February and March a number of sei whales were captured, an unusual occurrence for South Georgia.

Winter Season.—Four companies continued operations during the winter months, during which the take of whales showed a total decrease of fourteen as compared with the same period in the previous year. *Decrease*:—one right, one hundred and thirty-four fin, seventy-one humpbacks; *increase*:—four sperm, one hundred and eighty-four blue, four sei. The scarceness of humpbacks continued, but the increase in the number of blue and sperm whales was looked upon as a good omen for the next season.

1914-15: *Summer Season.*—Twenty-two licensed whale catchers were employed and the season proved very successful, owing chiefly to the large number of blue and fin whales taken. The whale catchers in use, being much larger and stronger than those employed in previous years, were consequently able to deal with the larger whales. Another encouragement to pursue the blue whale in preference to the humpback was the much higher reward offered by the companies than hitherto; in previous years the reward being the same for both species. The rates of reward for the various species are indicated in the table (relating to the South Shetlands) on page 93. Although on occasions the humpbacks appeared in large numbers, these animals were, in many cases, left to pursue their rambles in peace while the larger whales were plentiful. On one occasion a vessel hunting some ten miles off Cape Buller was drifting in a heavy fog, when a school of humpbacks came very close to the boat, and four of them were taken without the engine being moved. In conversation with the Magistrate the gunner of the vessel remarked: "I have never seen so many whales together; there must have been hundreds." Up to the last day in March similar reports were made by the gunners regarding the great number of humpbacks seen so late in the season. Owing to the War many of the stations worked shorthanded.

Winter Season.—Two companies continued operations throughout the winter, which was, however, very severe, and stormy weather in July and August often prevented whaling for several days consecutively. There was a considerable increase in the number of humpbacks taken up to the end of June, and, according to reports from the hunters, these whales were numerous the whole year through.

1915-16: *Summer Season.*—In the earlier part of the season twenty-two whale catchers were employed. One factory with three catchers did not arrive until the 15th February; and, from the 15th March, three additional catchers were employed, making a total number of twenty-eight at the end of the season. The production was good, although the larger whales were found to be in very poor condition, and the companies were subjected to many inconveniences, such as lack of coal and empty barrels. With the exception of a few which were taken some thirty or forty miles out, the whales on the whole were found near land. Owing to the necessity of a good output of the higher grade oils, the regulations regarding the utilisation of the whole carcass, and the use of buoy boats, etc., were relaxed completely for the time being. There was a considerable increase in the number of humpback whales taken in the half-year, the number—one thousand two hundred and sixty—being double that in the corresponding period of 1914-15. The Magistrate reported that, from his personal observations and reports from the gunners, so many whales had never been seen in any part of the world as in South Georgia waters during 1915-16. The high price of coal affected the output of guano.

Winter Season.—Three companies continued operations throughout the year, with excellent results. The increase in the take was two hundred and fifty-one blue, four hundred and twenty-eight fin, and one hundred and twenty-six humpback whales; but there was a decrease of ten in the take of right whales. The total number of whales captured was one thousand eight hundred and forty-nine, as compared with one thousand and forty-nine in the corresponding period of 1915-16.

1916-17: *Summer Season.*—Thirty-two whale catchers were employed as against twenty-eight in the previous season; there was, however, a decided decrease in the number of whales captured, but twenty-six sperm whales were taken on various parts of the coast. During the early months the weather was on the whole very boisterous, and whales were not so plentiful nor found so near land as in the corresponding period of the previous season. The blue and fin whales arrived rather later than usual, probably owing to the stormy weather. Few humpbacks were taken, but the figures of captures are not necessarily a guide to the numbers present of this whale.

Winter Season.—All the companies continued operations during the June quarter, and three until the end of the year. The usual boisterous weather prevailed. The number of whales taken up to the end of June was much less than for the same period in 1916, but this was chiefly owing to the scarcity of coal at the stations. Whales were very scarce in June, July, and August, and were seldom seen inside a circle of from forty to sixty miles from land. In consequence of the lack of coal the catchers were laid up for repairs much earlier than hitherto.

1917-18: *Summer Season.*—The number of whale catchers employed was practically the same as in the preceding summer, but there was again a decline in the number of whales. There was, however, a decided increase in the average production, the output of oil per whale being 66 barrels, as compared with 54·3 barrels in the corresponding period of the previous year. Little time was devoted to the manufacture of guano and bone meals owing to the pressing need for oil. More right whales were taken than in the two preceding seasons. The humpback did not appear in great numbers, and only fifty-eight of this species were taken. The blue whale was scarce during the whole season, and particularly after January. This was attributed to the mildness of the season consequent on the total absence of ice, and also to the distribution of the whale food being affected by an alteration in the usual currents due to the higher temperature of the water. It is recorded that the green whale food, which is most sought after by the blue whale, disappeared previous to the departure of that species, and was replaced by the red plankton favoured by the sei whale, which species appeared in large numbers after February and up to the end of March.

Winter Season.—Operations were not attended with much success since the weather was very stormy and whales very scarce, particularly in June, July, and August; the majority being caught to the north-west of the island at a distance of eighty miles or more from the nearest station. The decrease in the output of oil was chiefly the result of a strike in June and July. Production was, however, also affected by the fact that whales could only be found at long distances from the stations, and were, therefore, seldom fresh on arrival at the factories.

2.—*South Shetlands.*

Steam whaling operations in the South Shetlands were first conducted in the season 1905-6 by Mr. Alexander Lange, who operated in those waters, and also in the waters of the Falkland Islands, with one floating factory and two whalers. His total catch was three sperm whales and one hundred and twenty-two sei whales off the Falkland Islands, and fifty-eight whales (species not recorded) in the vicinity of the South Shetlands.

1907-8.—Four Companies operated during this season, but the statistics are incomplete. The total catch was between six hundred and fifty and seven hundred whales, and it is recorded that the two small steamers of Mr. Lange's expedition caught eighty-one blue whales, thirty-seven fin whales, and one hundred and six humpback whales. Most of the animals were found in the Bransfield Strait; but there were a great many fin whales in the Belgica Strait, and humpback whales were plentiful near Joinville Island.

1908-9.—The total catch of two of the Companies was as follows:—

Right.	*Blue.*	*Fin.*	*Humpback.*	*Total.*
1	74	148	530	753

The remaining two companies were reported to have captured about the same number of whales.

1909-10.—No detailed report is on record.

1910.-11.—One company operating three small steam whalers took five hundred and eighty-six whales, including forty-seven blue, one hundred and ten fin, and four hundred and twenty-nine humpback, yielding over seventeen thousand barrels of oil and fifty tons of whalebone, the total estimated value of which was about £70,000. Another company secured nearly seventeen thousand barrels of oil and twenty tons of whalebone. A floating factory, which followed the expedition but was not licensed to kill whales, dealt with between one thousand seven hundred and one thousand eight hundred carcasses. Whales were reported to be extremely plentiful, but to be going farther south.

1911-12.—The first floating factory arrived on 29th October, and the ten licensed factories, each with three steam whalers, were all on the whaling grounds by the 28th December. The arrival of some of the vessels was delayed by labour troubles in Europe. More than half of the whales caught this season were brought into Deception Harbour. At ordinary times the whales were caught within forty miles of Deception Island, and many were taken within a few miles of the entrance to the harbour. Whales were very scarce, and few were caught until about the 1st December; thenceforth they were plentiful throughout the whole season. Blue whales were caught all through the season, but most abundantly in the first half. Fin whales were not taken in the early part of the season, but were more plentiful in the latter half. Humpbacks were not nearly as plentiful as in the previous year. They were caught throughout the whole of the season, and their numbers seemed to be always about the same. Right whales were only taken during the latter part of the season. For a few days about the beginning, and towards the end of the season, some of the whalers went south to the Belgica Strait, which did not, however, prove so good a whaling ground as last year, although towards the end of the season whales were very plentiful.

1912-13.—Thirty-two licensed whalers were employed by the ten companies working, as compared with thirty in the previous season. Two additional catchers worked in connexion with the new shore station of the Hektor Company, the first whale carcass being hauled up on the platform of the station on the 24th December, 1912. Up to the 1st January, 1913, the weather could not have been better for whaling purposes, but after that date continual storms rendered the pursuit of whales on some days almost impossible. The Magistrate expressed the opinion that the time had now arrived when the industry in these waters would be centred in the Belgica Strait.

1913-14.—No detailed report was received for this season

1914-15.—The prospects of a successful season were not very bright at first, as pack ice was encountered as far north as 58° S. latitude, and it was not until the middle of December that the majority of the factories succeeded in reaching Deception Island. This was a serious set-back, as November and December are considered the best months. In the early part of the season whales, chiefly blue whales, were fairly numerous; in January and February they were not quite so numerous. In March whales were very numerous, blue whales especially.

In former years February has always been a very bad month, but this year, except in the Belgica Strait, it was fairly good. In March the fin whale is usually most numerous, but this year they were very seldom caught until the latter part of March. In the Belgica Strait the factories had a very successful time during December and January; blue whales were very numerous. In February the blue whales departed, and practically from the beginning of February until the 20th March there were almost no whales caught in the Strait. Although all the factories had very good catches, very few had a full cargo. If they had got in at the usual time there is no doubt that they all would have had full cargoes, excepting, perhaps, the one which arrived very late.

1915-16.—During this season nine companies were engaged in whaling, employing altogether twenty-nine whale catchers. With the exception of two, all the floating factories arrived between the 17th November and the 4th December; the remaining two arriving on the 15th and 26th December, respectively. In November and December the catch went very slowly, mainly on account of the prevailing bad weather—fog and wind—and the tremendous quantities of pack ice; Deception Harbour (Port Foster) was not wholly free of ice until the beginning of January. With the coming of January conditions improved; the "catch" went up by leaps and bounds; and five of the factories were able to proceed to Belgica Strait, where good catches were made. About the middle of February long

spells of bad weather set in, and fishing was once more delayed, although whales were still plentiful. By the end of March all the factories were completely loaded. Some humpbacks were taken, but there are now comparatively few of this species in the present fishing waters. Three small sperm whales were caught near to Deception Island on the 19th December, the first of this species reported to have been captured so far south. Blue and fin whales are to be found in almost equal numbers throughout the whole season, although fin whales are often observed to be more numerous after the middle of February.

1916-17.—During 1916-17 only four companies were engaged in whaling. The first factory arrived on the 24th November, the second following on the 12th December. The other two factories did not arrive until the 13th and 21st January, respectively. The conditions were excellent from the very beginning of the season. The abundance of whales, particularly blue whales, in the neighbourhood of the South Shetlands, throughout the entire season, is reported to have been nothing short of astounding. The Magistrate stated that, during his first visit to the Belgica Strait in January, 1917, the waters in the neighbourhood were simply teeming with whale spouts, and the catch became so prodigious at this period that the whalers were compelled to stop and confine themselves to two whales per day. By the end of February two of the factories left completely loaded, the two remaining factories following near the end of March. As formerly, the bulk of the oil was produced from the blue and fin whales.

1917-18.—Five companies, employing sixteen catchers, were engaged in whaling operations, but the results of the season were disappointing. Three of the factories did not begin operations until the middle of February, and all missed the best part of the season for blue whales. Also, owing to an accident to another of the factories necessitating the despatch of two of its catchers at different times to Punta Arenas, this factory had only two of its catchers operating for a considerable part of the time. In addition, a number of the gunners were shooting at the South Shetlands for the first time, and, although expert shots, were hampered by the lack of local knowledge. Although the number of catchers operating was greater than in the preceding season, the catch was only 1,114 as against 2,003 in 1916-17. The season is stated to have exactly resembled that of 1913-14, as from January onward whales were never abundant in Bransfield Straits. There was a marked absence of whale food, and icebergs and smaller ice were almost totally absent from the Straits during the season. The temperature of the water was found to be 36° Fahr. in February and March. Similar conditons prevailed in the Belgica Strait, with one exception, in the third week in January, when whales were plentiful. The whale catchers which proceeded to Punta Arenas reported large numbers of whales, mostly fin whales, between forty and a hundred miles from land. These whales were also seen by arriving factories, the reports extending from early January to late February; but no large numbers entered the whaling grounds at any time. Humpback whales were reported to be more common than in recent years, and formed a larger percentage of the catch than in 1916-17.

3.—*South Orkneys.*

The first attempt at whaling in the waters of this Dependency was made in the season 1907-8. Whales were plentiful, but the large quantity of ice interfered with whaling operations and forced the expedition to proceed to the South Shetlands. Actual whaling operations were first conducted at the South Orkneys in the season 1911-12, but no detailed report with regard to them was received.

In the season 1912-13 the first factory reached the edge of the ice on 20th November; two more factories arrived in mid-December, and the fourth on the 1st January, when it was just possible to get to the land. While waiting for the ice to break up the factories commenced fishing and obtained about two thousand barrels of oil before getting into harbour. The season was an exceptionally bad one as far as ice conditions were concerned. It is probable that the factories could get into the roadstead in mid-December if it was an "open" season, but, even in the most "open" seasons they can hardly expect to get in before this date. The weather conditions are so uncertain that to stay after the 15th March is not an attractive prospect, even for the hardiest whaler. Two notable features were the absence of right whales and the small number of humpbacks. Most of the whales were caught around Saddle Island, in Iceberg Bay, and on the south-west side of Coronation Island. In December whales were seen in very large numbers, and during January the catch was exceptionally good. Whales were scarce in February and fairly

plentiful again in March. The weather was excellent in December and January, bad in February, and good in March.

The statistics of the operations in the season 1913-14 were not accompanied by any detailed report.

The South Orkneys were visited by only one factory in the season 1914-15. Ice in one solid sheet surrounded the islands for quite a hundred miles to the north, with the result that an anchorage could not be reached until the 19th January, 1915. In spite of the unprecedented conditions prevailing, the season proved a record one for the sole factory which operated, and this result was attributed to its excellent equipment.

There has been no whaling at the South Orkneys since 1914-15.

4.—*South Sandwich Islands.*

The only record of whaling in this group is contained in the table of statistics (see Annexure IV.) relating to the operations conducted in the dependencies during 1911-12.

H. T. ALLEN.

9th June, 1919.

ANNEXURE I.

South Georgia Whaling Leases.

Leaseholders.	Date of Lease. (Commencement of leases for 21 years.)	Provision as to utilisation of Whale Carcasses.	Place leased.	Area.	Rent.	Remarks
				Acres.	£	
Cia Argentina de Pesca	1 Jan. '06	No provision for utilisation of whole carcass.	Grytviken ...	500	250	Allowed four whalers.
	1 Jan. '09 (for 18 years only)		Jason Harbour ...	30	100	
Sandefjord Whaling Co.	1 Jan. '08	Do.	Stromness Harbour	500	250	Allowed a third whaler on payment of an extra £100.
Tönsbergs Hvalfangeri.	1 Jan. '08		Husvik Harbour, Stromness Bay	500	250	Do.
Messrs. Bryde & Dahl.	16 Sept. '08	Do.	Godt Hull Harbour	114	250	Do.
Ocean Whaling Co.	1 Oct. '09	Whole carcass to be utilised.	New Fortune Bay	500	250	Limited to two whalers.
Messrs. Chr. Salvesen & Co.	1 Oct. '09	Do.	Allardyce Harbour, Cape Buller	500	250	Do
South Georgia Co.	1 Oct. '09	Do.	Leith Harbour, Stromness Bay	500	250	Do
Southern Whaling and Sealing Co.	1 July '11	Do.	Prince Olaf Harbour	500	250	Do.

ANNEXURE II.

LIST OF LICENCES ISSUED FOR (*a*) THE SOUTH SHETLANDS AND GRAHAM LAND, (*b*) THE SOUTH ORKNEYS FOR THE 1914-15 SEASON; AND (*c*) FOR THE SOUTH SANDWICH ISLANDS FOR THE 1912-13 SEASON.

(*a*) *South Shetlands and Graham Land*, 1914-15.

1. Hektor Whaling Co. (N. Bugge), Tönsberg, Norway.*
2. Odd Whaling Co. (Haldor Virik), Sandefjord, Norway.
3. Sociedad Ballenera de Magallanes, Punta Arenas, Chile.
4. Laboremus Whaling Co. (T. Dannevig & Company), Sandefjord, Norway.
5. Aktieselkabet "Hvalen" (Andorsen & Neumann), Christiania, Norway.
6. Southern Whaling Co. (P. Bogen), Sandefjord, Norway.
7. Norge Whaling Co. (C. Nielsen & Company), Larvik, Norway.
8. Salvesen & Co., Leith.
9. Örnen Whaling Co., Kamfjord pr. Sandefjord, Norway.
10. Nor Whaling Co., Kamfjord, Sandefjord, Norway.

* A floating factory and two catchers were also used under the terms of this Company's lease at Deception Island.

(*b*) *South Orkneys*, 1914-15.

1. Rethval and Thule Whaling Cos. (H. Fredriksen), Christiania, Norway.
2. Hektor Whaling Co. (N. Bugge), Tönsberg, Norway.
3. Normanna Whaling Co. (Haldor Virik), Sandefjord, Norway.
4. Haugesund Whaling Co. (Erich Lindoe), Haugesund, Norway.

(*c*) *South Sandwich Islands*, 1912-13.

1. Thule Co.
2. Albatros Co.
3. A. Nilsen, Sandefjord.
4. Normanna Co.
5. Kosmos Co.
6. Lars Christensen, Sandefjord.

ANNEXURE III.

(*a*) *Laws*

ORDINANCE No. 5 of 1908 (as amended by subsequent Ordinances No. 5 of 1912, No. 5 of 1915, and No. 9 of 1915) forbids the killing, taking, or hunting of whales in Colonial waters without a licence. Subject to any regulations made by the Governor in Council the Governor is empowered to settle in regard to each licence:

(*a*) The period;
(*b*) The number and tonnage of vessels to be employed in the taking of whales;
(*c*) The limits of colonial waters within which whales may be taken;
(*d*) In which of the Dependencies the licensee may use the harbours by virtue of his licence.

The Colonial Secretary, or such other officer as the Government may appoint, is empowered to grant whaling licences and licences to utilise whale carcasses by means of a floating factory. The fees payable are:—

(1) For a whaling licence, £100;
(2) For a floating factory: not less than £100, and not more than £200, as the Governor in Council may approve.

The penalty for taking whales without a licence is £300 for each offence in the case of the master or owner, and £100 in the case of other offenders. The penalty payable by an owner or master may be recovered by the arrest and sale of the vessel.

The Ordinance also makes it an offence, subject to a penalty of £100,

(*a*) to have unlawful possession of whale oil or whalebone;
(*b*) to employ, without authority, any vessel for manufacturing, towing, or buoying whale carcasses within Colonial waters;
(*c*) to employ any licensed vessel to tow, buoy, or manufacture in Colonial waters whale carcasses taken outside Colonial waters by any unauthorized vessel.

The Governor in Council may make regulations for:—

(*a*) Fixing the conditions of licences;
(*b*) Regulating the number of licences to be granted in any one year;
(*c*) Defining the limits within which a licence-holder may take whales;
(*d*) Regulating the number of whales to be taken;
(*e*) Regulating the disposal for forfeited whales, oil, etc.; and
(*f*) Generally for carrying out the provisions of the Ordinance.

The owner or lessee of any land may take possession of a derelict whale with permission of the Governor in Council and on payment of a royalty. Provision is made for taking whales for scientific purposes.

During the War Ordinances were passed requiring the products of the whaling industry to be brought to, and sold in, the United Kingdom.

(*b*) *Regulations.*

(*a*) *South Georgia.*—The regulations

(1) Prohibit leaseholders from killing or shooting any whale calf or any female whale which is accompanied by a calf;
(2) Reserve to the Crown any dead whale abandoned or thrown up on the seashore;
(3) Prescribe penalties for breaches of the regulations.

(*b*) *Other Dependencies.*—The regulations

(1) Provide for the issue of annual licences (October to September);

(2) Prohibit licensed vessels from catching whales for a Company other than that mentioned in the licence;

(3) Authorize the use of (*a*) two floating factories, in conjunction with two whale catchers—fee £200; and (*b*) a third whale catcher—fee £100;

(4) Require the provision of pressure boilers for dealing with the residue of the carcass;

(5) Prescribe that separate licences shall be issued for :

(*a*) The South Shetlands and Graham Land;

(*b*) The South Orkneys;

(*c*) The Falkland Islands;

(*d*) The South Sandwich Islands;

but that no further licence or lease for whaling purposes shall be issued, with the exception of renewals of existing annual licences for two floating factories and two whale catchers, or for a third whale catcher, without the permission of the Governor in Council;

(6) Require every licensed vessel at the end of the season to proceed direct to a port of entry and to report full particulars of the catch, including the number of barrels of oil and the quantity of baleen and guano obtained;

(7) Prohibit licensees from killing or shooting any whale calf or any female whale which is accompanied by a calf;

(8) Reserve to the Crown any dead whale abandoned or thrown up on the sea-shore;

(9) Prescribe penalties for breach of the regulations.

(*c*) In consequence of the War and the necessity for obtaining a maximum output of oil, the Governor was empowered by regulations made on the 13th September, 1916, to authorize, during the continuance of the War, the departure from any or all of the provisions of the above-mentioned regulations as to him may seem fit and expedient.

(*c*) *Leases and Licences.*

(*a*) *Form of Lease.*—Some particulars of the whaling leases already granted in South Georgia will be found in Annexure I. In addition, the lessees are prohibited from taking, removing, appropriating, killing, or in any way using for their own benefit or for the benefit of any other person or persons, any product or animal whatsoever on the island of South Georgia or any island adjacent thereto. The right to win and take mineral oil is reserved to the Crown. The lease also specifies the number of vessels which may be employed, and, in the case of the later leases, requires the utilisation, without waste, of the whole carcass of all whales taken. The lessees are required (*a*) to keep an accurate record of meteorological observations and to furnish full particulars of such observations to the Governor of the Falkland Islands; (*b*) to keep in stock a reasonable quantity of coal and provisions to be supplied at cost price to any ship requiring coal or provisions; (*c*) to establish and maintain and exhibit two leading beacon lights as guides to shipping; (*d*) to give certain facilities of access to the shore on which the site leased is situate: and (*e*) to furnish to the Governor of the Falkland Islands an annual report respecting their operations.

(*b*) *Form of Licence.*—The licences issued under the Ordinance provide for the payment of the fee either at the Colonial Treasury or to the Crown Agents. It specifies the names of the vessels to be employed in taking whales; the limits within which they may be taken (i.e., in the territorial waters of a specified Dependency) and the harbours to be used; and it requires the licensee to render an accurate account of the number and description of the whales taken and the quantity of oil, bone, and guano obtained.

Annexure IV.

Statistics of Catch of Whales at each of the Dependencies of the Falkland Islands and the number of Whale Catchers employed.

Season. (October—September.)	Dependency.	Right.	Sperm.	Blue.	Fin.	Humpback.	Other.	Total.	No. of Whale Catchers employed.	Notes.
1909-10	South Georgia*	37	4	26	58	3,391	—	3,516	17	* Complete statistics for the other Dependencies not available.
1910-11	South Georgia*	79	—	85	168	6,197	—	6,529	19	† Bottlenose.
1911-12	South Georgia	82	4	298	516	5,635	—	6,535	21	‡ No whaling has taken place at the South Sandwich Islands since 1911-12.
	South Shetlands... ...	17	—	892	1,727	2,174	3†	4,813	30	
	South Orkneys	—	—	67	67	114	—	248	2(?)	
	South Sandwich‡ ...	—	—	4	11	13	—	28	2(?)	§ Sei.
1912-13	South Georgia	6	9	317	2,157	2,360	1†	4,850	21	[ ] Details not furnished by two Companies whose total catch amounted to 715 whales.
	South Shetlands... ...	3	—	1,761	2,300	976	4†	5,044	32	
	South Orkneys	—	—	199	442	138	–	779	8(?)	¶ No whaling operations have taken place at the South Orkneys since 1914-15.
1913-14	South Georgia	66	21	940	1,716	512	94§	3,349	21	
	South Shetlands... ...	[3]	—	[1,472]	[2,092]	[977]	—	5,259	32	
	South Orkneys	3	—	29	480	109	—	621	6(?)	** 22 to 15th February; 25 from that date to 15th March, and 28 thereafter till the winter.
1914-15	South Georgia	20	1	2,313	1,940	823	—	5,097	22	
	South Shetlands... ...	2	—	1,796	1,679	656	—	4,133	32	
	South Orkneys ¶... ...	—	—	94	275	10	2†	381	3	
1915-16	South Georgia	12	1	3,026	2,744	1,578	—	7,361	28**	†† In addition one Company operated from the 1st to 8th January only with 3 catchers; the floating factory then proceeding to the South Shetlands with 4 catchers. One of the floating factories from the South Shetlands also operated with 2 catchers during the latter part of the June quarter.
	South Shetlands... ...	6	3	1,845	2,358	219	—	4,431	29	
1916-17	South Georgia	12	35	2,440	1,606	378	—	4,471	32	
	South Shetlands... ...	—	—	1,380	602	21	—	2,003	12	
1917-18	South Georgia	85	37	1,871	1,144	60	49§	3,199	31 to 32††	§§ 1 Bottlenose, 5 Pike (*B. acutorostrata*).
	South Shetlands... ...	13	—	397	627	71	6§§	1,114	16	

ANNEXURE V.

Statistics of Catch at South Georgia.

Season. (October—September.)	Period.	Right.	Sperm.	Blue.	Fin.	Humpback	Other.	Total.
1910-11*	October—March	49	—	76	97	5,299	—	5,521
	April—September	30	—		71	898	—	1,008
1911-12*	October—March	71	3	208	299	5,100	—	5,681
	April—September	11	1	90	217	535	—	854
1912-13*	October—March	2	7	212	1,724	2,251	Bottlenose, 1	4,197
	April—September	4	2	105	433	109	—	653
1913 14	October—December	1	11	140	700	204	—	1,056
	January—March	62	4	511	717	270	Sei, 90	1,654
	April—June	2	5	143	275	37	Sei, 4	466
	July—September	1	1	146	24	1	—	173
1914-15	October—December	—	1	498	777	344	—	1,620
	January—March	4	—	1,438	699	287	—	2,428
	April—June	16	—	288	415	192	—	911
	July—September	—	—	89	49	—	—	138
1915-16	October—December	1	1	851	876	680	—	2,409
	January—March	5	—	1,547	976	580	—	3,108
	April—June	5	—	487	771	314	—	1,577
	July—September	1	—	141	121	4	—	267
1916-17	October—December	1	18	643	586	217	—	1,465
	January—March	2	8	1,277	759	118	—	2,164
	April—June	7	2	365	228	43	—	645
	July—September	2	7	155	33	—	—	197
1917-18	October—December	4	23	1,030	258	83	—	1,348
	January—March	21	7	786	522	25	Sei, 42	1,403
	April—June	10	7	30	225	2	Sei, 7	281
	July—September	—	—	28	139	—	—	167

* Separate figures for each quarter are not available in respect of the seasons 1910 11, 1911-12, 1912-13.

Annexure VI.

Statistics of Production of Whale Oil, Baleen, and Guano, in each of the Dependencies of the Falkland Islands.

Season. (October—September.)	Dependency.	Oil.		Baleen.		Guano.		Total Value.	Notes.
		Barrels.	Value.	Tons.	Value.	Bags.	Value.		
			£		£		£	£	
1909-10	South Georgia* ...	104,816	289,842	63	9,670	3,130	1,565	251,077	*Complete statistics for the other Dependencies not available.
1910-11	South Georgia* ...	189,363	508,526	104	21,277	16,050	9,912	534,715	
1911-12	South Georgia ...	212,262	496,951	173	19,905	48,737	23,056	539,912	
	South Shetlands ...	148,770	413,622	383	13,360	—	—	426,982	
	South Orkneys ...	7,000	18,656	20	400	—	—	19,056	
	South Sandwich† ...	1,000	2,500	—	—	—	—	2,500	†No whaling has taken place at the South Sandwich Islands since 1911-12.
1912-13	South Georgia ...	212,992	551,062	284	5,436	77,187	33,383	589,881	
	South Shetlands ...	198,410	599,886	309	8,100	950	570	608,556	
	South Orkneys ...	26,031	not stated.	—	—	—	—	—	
1913-14	South Georgia ...	176,487	464,320	148	11,060	85,775	37,480	512,860	
	South Shetlands ...	221,628	887,712	111	275	10,148	6,187	894,174	
	South Orkneys ...	21,750	87,000	20	30	—	—	87,030	
1914-15	South Georgia ...	270,507	731,926	21	1,470	85,393	37,321	770,717	
	South Shetlands ...	206,936	560,000	60	735	11,011	5,505	566,240	
	South Orkneys‡ ...	14,000	46,600	—	—	—	—	46,600	‡No whaling operations have taken place at the South Orkneys since 1914-15.
1915-16	South Georgia ...	346,269	1,087,820	6	1,940	83,651	40,128	1,129,887	
	South Shetlands ...	212,536	778,564	117	1,580	18,952	13,266	793,360	
1916-17	South Georgia ...	268,327	1,010,740	31	1,750	9,705	2,601	1,015,091	
	South Shetlands ...	92,760	479,260	—	—	Nil.	Nil.	479,260	
1917-18	South Georgia ...	202,503	1,100,000	8½	—	994	—	1,100,000	
	South Shetlands ...	55,973	466,000	—	—	Nil	Nil	466,000	

Note.—In general the figures are taken from the periodical returns, but in some cases from the Blue Book Reports. The valuations are conventional customs valuations and are usually much below market prices. As indicated on page 5 of the memorandum the statistics do not represent the full output of baleen.

ANNEXURE VII.

Total Catch of Whales and Production of Oil and Guano therefrom at (1) *South Georgia and* (2) *South Shetlands. The Average Production per Whale in each year is also shown.*

(1) *South Georgia.*

Season. (October—September.)	Whales.	Oil.	Guano.	Average per Whale.	
				Oil.	Guano.
		Barrels.	Bags.	Barrels.	Bags.
1909-10	3,516	104,316	3,130	29·7	0·9
1910-11	6,529	189,363	16,050	29·0	2·5
1911-12	6,535	212,262	48,737	32·5	7·5
1912-13	4,850	212,992	77,187	43·9	15 9
1913-14	3,349	176,487	85,775	52·7	25·6
1914-15	5,097	270,507	85,393	53·1	16·8
1915-16	7,361	346,269	83,651	47·0	11·4
1916-17	4,471	268,327	9,705	60·0	2.2
1917-18	3,199	202,503	994	63·3	0·3

(2) *South Shetlands.*

1911-12	4,813	148,770	—	30·9	—
1912-13	5,044	198,410	950	39·3	0·2
1913-14	5,259	221,628	10,148	42·1	1·9
1914-15	4,139	206,936	11,011	50·1	2·7
1915-16	4,491	212,536	18,952	48·0	4·3
1916-17	2,003	92,760	Nil.	46·3	Nil.
1917-18	1,114	55,973	Nil.	50·2	Nil.

APPENDIX VI.

COMMERCIAL USES OF THE PRODUCTS OF THE WHALING INDUSTRY.

1.—WHALE OIL.

BEFORE the War whale oil was used for burning, lubrication, soap-making, fibre dressing, and currying leather. Since the War it has been in great demand in this country for the manufacture of glycerine for munition purposes, and to some extent in connexion with the manufacture of margarine. It is stated that before the War considerable quantities were used for the production of edible fats on the Continent, especially in Germany, and, since the War began, this use is believed to have been largely developed, especially in Scandinavia.

"According to the equipment of the blubber-rendering stations the yield of the oil and also its quality vary. In the most modern works the blubber is stripped clean from flesh immediately after the arrival of the whaler, and care is taken to leave as little flesh as possible on the blubber. The latter is then cut into strips, which are thrown into chopping machines, whence the comminuted mass is immediately delivered into melting pans, and boiled with steam. Five different qualities of whale oil are produced. The best quality is the oil which first runs off the blubber at the lowest temperature, and is known in commerce as 'Whale Oil No. 0'; it is of a pale yellow colour, and has but a faintly fishy smell. This oil contains a very small quantity of free fatty acids. The best brands are water-white, and are free from volatile fatty acids. On further boiling the second quality ('Whale No. 1') runs off; it is a little darker in colour, although still pale yellow. Its fishy smell is more pronounced than the oil of the first running.

"These two qualities of oil are stored in large vessels, whereby they become clarified whilst depositing 'stearine,' which is filtered off, pressed in hydraulic presses, and sold as 'whale tallow,' 'whale stearine,' for soap-making. When tallow is high in price, it is sometimes adulterated with

whale stearine; this will be detected by the high iodine value of the liquid fatty acids, and also by the yield of insoluble bromides."

"The residual mass in the boiling pans, together with the flesh of the whale, is cut up into strips or fairly large lumps, and is 'tried down' in a digester under a pressure of 40-50 lb. Thus the oil classed as 'No. 2 oil' is obtained. This oil has a brown colour and a strongly developed fishy smell; its proportion of fatty acids is considerably higher than in 'Oil No. 1.' In some stations 'Whale Oil No. 2' is made from the blubber residues only, and does not contain any oil from the flesh. Hence it represents a superior article to the 'No. 2 Oil,' described in the preceding lines."

"The bones are also worked up in the same manner, and yield a still inferior quality of oil. Such oil ('Whale Oil No. 3') is darker still, has a more strongly developed odour, and a high percentage of free fatty acids. 'Whale Bone Oil' of commerce is, however, not exclusively made from the bones, except in those cases where the product is sold as 'Bone Oil.'"

"The oil obtained after the flesh has undergone some pronounced putrefaction ('Carcase Oil,' 'Whale Oil No. 4') is still darker, and more objectionable as regards smell, and contains a higher proportion of free fatty acids. In the same three lowest qualities the proportion of unsaponifiable matter is considerable."

"It must of course be understood that the different qualities described above, with the exception of 'Whale Oil No. 0,' vary within wide limits, so that no definite standards can be laid down."—("Chemical Technology and Analysis of Oils, Fats, and Waxes," by Lewkowitsch, Vol. II., pages 454-7.)

2.—Sperm Oil.

Sperm oil is obtained from the head cavity and also from the blubber of the sperm whale or cachalot. After being taken from the animal it deposits the solid spermaceti, the fluid that remains being the sperm oil of commerce. The oil, whether taken from the head or the blubber, is pure sperm oil, but that taken from the head contains more spermaceti than that from the blubber. The oil obtained from other parts of the sperm whale, such as the bones or flesh, is not a pure sperm oil, but has some of the characteristics of sperm oil. It contains little or no spermaceti and is sold as sperm meat oil. Sperm oil is also obtained from the bottle-nosed whale, but contains very much less spermaceti than the oil from the sperm whale.

Refined sperm oil is a most valuable lubricant for small and delicate machinery, such as watches and sewing machines. Spermaceti was at one time much sought after for making the finest quality of candles, as its melting point is very high, and candles made from it burn very cleanly.

3.—Stearine.

"The rank fishy odour which adheres persistently to these 'stearines,' i.e., fish stearines and whale grease, renders them almost useless for soap-making, and they are therefore chiefly worked up into degras-substitutes, stuffing-greases, etc. This holds good also of the distilled fatty acids from fish oils, which were brought into commerce on the Continent under the fancy name of 'Olid' fatty acids. Modern modes of rendering whales, etc., make the first-class stearine an important and valuable article of commerce."

"The best classes of greases considered in this chapter are used as substitutes for tallow, lard, etc., in the soap and candle industries. Lower kinds, provided their colour be not too objectionable, and the proportion of unsaponifiable matter be not too high, may be used for low-class soaps. Still lower products are worked up into lubricating greases, degras-substitutes, and stuffing-greases. The lowest kinds, such as 'animal grease' and 'animal oil,' are treated with sulphuric acid, and subsequently worked up into 'oleine' and 'stearine' by distillation, much in the same manner as 'black grease' is treated."—("Chemical Technology and Analysis of Oils, Fats, and Waxes," by Lewkowitsch, Vol. III., page 411.)

4.—Whalebone.

The value of whalebone, baleen, or finners (as the whalebone of the species of fin whales is commonly called), had so decreased before the War that it was questionable whether the expense of the marketing was not heavier than the value

realized. There was no doubt that it did not pay to ship humpback finners at the prices then obtainable; at present, however, there seems to be a fair market for the whalebone of fin whales, probably chiefly in view of the shortness of supplies.

"To prepare whale bone for its economic applications the blades or plates are boiled for about twelve hours till the substance is quite soft, in which state it is either cut into narrow strips, or into small bristles and filaments, according to the use to which it is to be devoted. It is light, flexible, tough, and fibrous, and its fibres run paralled to each other without inter-twisting. One of its earliest uses referred to in the 13th century was to form the plumes on helmets."

"It has been found practicable to employ flexible steel for several purposes to which whale bone was formerly applied, especially in the umbrella and corset industries in which steel is now almost exclusively used; whale bone, however, is still in demand among dressmakers and milliners; but is principally used in the brush trade, chiefly in making brushes for mechanical purposes, since it offers the great advantage of being procurable in strips or filaments, long or short, thick or thin, according to requirements."—(*Encyclopædia Britannica*, 11th Edition, Vol. XXVIII., page 570.).

5.—Other Products.

"(*a*) *Guano and Meal.*—Three products may be obtained from the dried meat and bones. Firstly, whale meat meal, manufactured exclusively from absolutely fresh whale flesh. This is a most nutritious and wholesome foodstuff, containing seventeen-and-a-half per cent. proteid, and is largely used for feeding cattle. Secondly, whale guano, made from the remaining flesh and about one-third of bones. The analysis shows about 8·50 per cent. ammonia and about twenty-one per cent. tribasic phosphates. Thirdly, bone meal, made exclusively from bones, and analysing about four per cent. ammonia and about fifty per cent. phosphates. The whole of the dried carcase may also be made into one product, forming a rich guano and containing from ten per cent. to twelve per cent. ammonia and seventeen per cent. to twenty-four per cent. phosphates."—("Report on the Scientific Results of the Scottish National Antarctic Expedition," Vol. IV., page 483.)

Whale manure can be applied to all the purposes for which nitrogenous and phosphate manures are suitable.

"(*b*) Ambergris is a solid, fatty, inflammable substance of dull grey or blackish colour, which occurs as a concretion in the intestines of the spermaceti whale, and is found floating upon the sea, on the sea coast, or in the sand near the sea coast. It is also sometimes found in the abdomen of whales, always in lumps of various shapes and sizes, weighing from $\frac{1}{2}$-oz. to 100 lb. or more. The use of ambergris in Europe is now entirely confined to perfumery, though it formerly occupied no inconsiderable place in medicine."—(*Encyclopædia Britannica*, 11th Edition, Vol. I., page 794.).

"Ambergris is a product of disease, as it is not met with in the healthy animal. It contains eighty-five per cent. of the fragrant substance ambreine, which is extracted by digestion with alcohol."—("Animal Products," Simon, page 390.)

"By itself ambergris is not much used. It finds its chief application in combination with other odours, or as an addition to some perfumes in order to make them lasting."—("Perfumes and their Preparation," Atkinson, page 58.)

H. T. ALLEN.

17th August, 1918.

APPENDIX VII.

MEMORANDUM OF INTERVIEW WITH MR. HOLMAN KINGDON, M.A., OF THE FIRM OF MESSRS. JOSEPH CROSFIELD & SONS, LIMITED, WARRINGTON, AND PRESIDENT OF THE SOAPMAKERS' FEDERATION.

MR. KINGDON stated that the development in the use of whale oil during the War might be described as phenomenal. In fact, without whale oil the Government would have been unable to carry out both its food and munition campaigns, since the use of this oil in the production of glycerine had freed other fats for edible purposes.

Prior to the War glycerine was a by-product of the soap-making industry. During the War the relative positions of the two products had been reversed owing to the enormous demand for glycerine, with the result that soap-making had become a by-product of the glycerine industry, and would doubtless so continue until the advent of peace, when the industry may be expected to resume its normal course.

For the purposes of the soap-maker fats may be classified as follows:—

(1) The tallow class, comprising all hard and hardened fats;
(2) The nut oil class, palm kernel oil, coco-nut oil, etc.; and
(3) The soft oil class, such as cotton-seed oil, linseed oil, and soya-bean oil.

In its natural condition whale oil is a soft oil and is useless for the purposes of the hard soap maker unless hydrogenated. This process produces a fine, white, and odourless hard fat, which is in reality a tallow substitute, and may therefore be included in the first of the above-mentioned classes.

Whale oil is classified into five grades, namely, 0, 1, 2, 3, 4; the highest grades being the lightest in colour and containing a minimum of fatty acids. As the two highest grades have now been practically amalgamated and are always dealt with together as grade 0/1, they are not separated in the following paragraphs. The proportions of fatty acid in each grade is as follows:—

Grade 0/1 = under two per cent.
Grade 2 = two per cent. to six per cent.
Grade 3 = six per cent. to fifteen per cent.
Grade 4 = over fifteen per cent.

Before the War the soap-makers used grades 0/1 and 2 only. Under the extreme pressure of scarcity of oil and fats they now make use of all the grade 3 oil available; but, even in present circumstances, they do not use grade 4 oil.

The disadvantages of the two lower grades are that, owing to impurities, the oil will not harden to the same degree as the better grades. Also the process of hardening is so much slower that the output of the plant is enormously retarded and the cost of production is consequently increased. At one time the by-products of the hydrogenating process were not used, but nowadays there is no waste with the exception of about 0·25 per cent., which disappears in the process. At present practically all whale oil is graded on the fatty acid basis, but considerable difficulty was experienced in obtaining the consent of the whalers to this classification.

Before the War, with whale oil at £20 a ton, there was a difference of about 30s. a ton in the value of each grade. At the present time, taking the value of the best oil at £60 a ton, the differences are roughly £2 between the grade 0/1 and grade 2 oils, £5 between the grade 2 and grade 3 oils, and £2 between the grade 3 and grade 4 oils.

As regards the arrangements for the acquisition on behalf of the Government of all the whale oil brought to this country, Mr. Kingdon explained that the Ministry of Munitions made an agreement with the three firms of hydrogenators, namely, Messrs. Lever, of Port Sunlight, Messrs. Ardol, of Selby, and Messrs. Crosfield, of Warrington, under which these three firms contracted to utilize the whole of the whale oil brought to this country. Originally grades 0/1 and 2, after being hardened, were utilized by the soap-makers for the production of glycerine; the lower grades, Nos. 3 and 4, being supplied to other trades. These latter grades were disposed of by agents, and the profits on the sales were credited to the three contracting firms above mentioned. But, as already stated, a large proportion of grade 3 oil is now used by the soap-makers.

The total capacity of the three hardening plants in this country is about 2,500 tons a week on the basis of a hardness of 39-41° titre. There should therefore be no difficulty in dealing with all the whale oil that is likely to arrive either now or after the War.

The price paid by the Ministry of Munitions for crude glycerine is £59 10s. per ton, the proportion of glycerine in fats and oils being, on an average, ten per cent. Soap-makers' materials, which at one time cost £20 to £30 a ton, have now risen to £80 to £90 a ton. As the price of crude glycerine is constant at £59 10s. the increased cost of the fats and oils used in the production of soap has had to be passed on to the public in the shape of an increase in the price of soap.

As regards the relative value of the various oils and fats used for edible and other purposes, Mr. Kingdon stated that 0/1 whale oil, when treated carefully and hardened, becomes to all intents and purposes an edible tallow. It has not, however, been much used in the manufacture of margarine, since the manufacturers of that commodity in the United Kingdom prefer vegetable oils, and, in so far as animal oil is required, use Premier Jus.

Hardened whale oil is worth about £2 a ton less than tallow, for which it is a substitute; this difference is perhaps at present not very material to the soap-maker, seeing that the controlled price of tallow is now £90 a ton

As regards the production of glycerine there is no difference between the oils, the glycerine produced from whale oil being perfectly normal.

In reply to an inquiry, Mr. Kingdon said that he imagined that it would be impossible to apply the process of hydrogenization to whale flesh in order to make it more suitable for food by getting rid of the odour; and he thought that the extraction of the oil from the flesh would probably destroy its nutritive value.

As regards the demand for glycerine after the War, Mr. Kingdon said that he would prefer not to express any opinion, since there are so many variable factors involved that it is impossible to form any considered judgment on the matter. He pointed out, however, that the consumption of whale oil after the War would depend on the edible and soap-making trades, and that the falling off in the demand for glycerine would not in any way affect the utilization of any oil or fat, since, as he had already pointed out, glycerine would once more become a mere by-product of the soap industry.

In the British Empire the production of fats and oils exceeds the consumption. The Empire production forms an enormous proportion of the world's production. With the exception of copra in the Dutch East Indies, and the linseed crops of the Argentine, there is no production on an extensive scale elsewhere than in the British Empire.

Mr. Kingdon strongly urged the desirability of fostering and safeguarding the supplies of whale oil after the War; and said that if there were any steps that the Colonial Office could take to make the Government control over whale oil more secure those steps should certainly be taken. He considered that such steps were absolutely necessary in the interests of this country; and saw no possibility of the soap-maker becoming independent of whale oil after the War through a glut of other oils and fats.

In answer to an inquiry, Mr. Kingdon said that he has no knowledge of sperm oil except that it was not suitable for hydrogenization. If any of it were mixed with grade 0/1 whale oil the mixture would not harden well.

Mr. Kingdon handed in the appended statistics.

27th August, 1918.

WHALE OIL.

	World's catch. Barrels.	*Catch of Norwegian Companies.* Barrels.	*Import into United Kingdom.* Barrels.
1906	75,000 ...	51,000 ...	——
1907	125.000 ...	65,250 ...	——
1908	150,000 ...	69,000 ...	——
1909	240,000 ...	128,700 ...	——
1910	320,000 ...	187,800 ...	——
1911	625,000 ...	360,000 ...	——
1912	780,000 ...	520,000 ...	40,000
1913	800,000 ...	630,000 ...	32,500
1914	750,000 ...	570,000 ...	32,500
1915	630,000 ...	460,000 ...	35,000
1916	634,000 ...	389,000 ...	95,000
1917	358,000 ...	258,000 ...	44,000
1918	—— ...	—— ...	50,000 (estimated)

APPENDIX VIII.

MEMORANDUM ON THE PRESENT POSITION OF THE SOUTHERN WHALING INDUSTRY.

1.—Species of Whales Captured.

The questions (i) whether the southern whales are specifically identical with their northern representatives, and (ii) whether definite races are to be distinguished among the southern species, cannot at present be regarded as definitely settled. For practical purposes it may be assumed provisionally that the southern forms are not specifically distinct, and that the species are not divisible into distinct races. On these assumptions the species which require consideration are:—

(i) Humpback (*Megaptera nodosa*) [*M. lalandii*];
(ii) Fin whale (*Balænoptera physalus*) [*B. quoyii*];
(iii) Blue whale (*Balænoptera musculus*) [*B. intermedia*];
(iv) Right whale (*Balæna glacialis*) [*B. australis*];
(v) Sperm whale (*Physeter catodon*);
(vi) Sei whale or Rudolphi's rorqual (*Balænoptera borealis*).

Other species of Cetacea are known to occur in southern waters; and as one or two of these are occasionally captured, while others might at any time attract the attention of the whalers, it may be well to mention the following species:—

Bryde's rorqual (*Balænoptera brydei*), a small rorqual resembling the sei whale, said to be a distinct species, and already hunted in South Africa; the lesser rorqual (*Balænoptera acutorostrata*), which was found abundantly in Ross Sea by the "Terra Nova" Expedition, 1910; the killer (*Orcinus orca*); the pilot whale, blackfish or caa'ing whale (*Globicephala melæna*); and the bottle-nosed whale (*Hyperoodon rostratus*); the last four being species which reach a length of between 20 and 35 feet.

Of the species enumerated above as (i)-(vi), the sei whale does not seem to be of much practical importance farther south than the Falkland Islands; while the sperm whale and the right whale are captured in numbers which are almost negligible compared with those of the three remaining species. So far as sub-Antarctic whaling is concerned, the humpback, the fin whale, and the blue whale together constitute an overwhelming proportion of the annual captures at the present time.

2.—History of the Whaling Operations.*

It will be sufficient to point out here that the southern whaling industry is no more than fourteen or fifteen years old. The South Georgia whaling was inaugurated by Captain C. A. Larsen, who founded a whaling company in the autumn of 1904, commencing operations in December of that year; while a floating factory visited the South Shetlands in January, 1906. Whaling was begun in the South Orkneys in 1911. For several years whaling companies have also operated at various localities on the east and west coasts of Africa (since 1909) and in South America. The activities of these companies may have a very important bearing on the present inquiry; while those of the companies working in Australia and New Zealand are of less immediate consequence

3.—Number of Whales caught annually since the Season 1910-1911.

South Georgia Whaling Season, October-March.

A.—Actual Numbers.

—	1910-11	1911-12	1912-13	1913-14	1914-15	1915-16	1916-17
Humpback	5,299	5,100	2,251	474	631	1,260	335
Fin Whale	97	299	1,724	1,417	1,476	1,852	1,845
Blue Whale	76	208	212	651	1,936	2,398	1,920
Total (of the three species.) ...	5,472	5,607	4,187	2,542	4,043	5,510	3,600

* For much valuable information on this subject, and on other matters connected with whales and whaling, reference may be made to "Whale Hunting with Gun and Camera," by R. C. Andrews (New York and London, D. Appleton & Company, 1916).

B.—Percentages (of the total of the three species).

——	1910-11	1911-12	1912-13	1913-14	1914-15	1915-16	1916-17
Humpback	96·8	90·9	53·8	18·6	15·6	22·9	9·3
Fin Whale	1·8	5·3	41·2	55·7	36·5	38·6	37·4
Blue Whale	1·4	3·7	5·1	25·6	47·8	43·5	53·3
Total	100·0	99·9	100·1	99·9	99·9	100·0	100·0

The figures for the last season were materially affected by tonnage difficulties, due to the War; but in the season 1915-1916 this was not the case.

The curves constructed from table "A" are very striking; showing, in the case of the humpback, an extremely steep fall from 1911-1912 to 1913-1914, with some recovery in the next two summers, although falling far short of the figures recorded in the first two seasons. The curve for the fin whale rises steeply from 1911-1912 to 1912-1913; and, with some fluctuations, rises to 1915-1916. The curve for the blue whale has risen continuously till 1915-1916, the principal rise commencing in 1913-1914.

The diminished catch of humpbacks during recent years demands the most serious consideration, but in interpreting these figures it should be remembered that at the commencement of operations this species was regarded as the principal object of the chase, and actually constituted more than 90 per cent. of the total catch of the three species in the principal whaling seasons 1910-11 and 1911-12. The fin whale and the blue whale are much larger than the humpback, which could be conveniently dealt with by the whaling vessels at first in use. Since that time larger whalers and stronger tackle have been employed: and these changes have enabled the whaling companies to attack the fin whale and the still larger blue whale: the larger kinds naturally giving a greater yield of oil and other valuable products.

It may be admitted at once that this preference for the larger kinds is likely to have some effect on the relative numbers of the species captured. But it may be noted that if this selective hunting were the sole reason for the diminished capture of the small humpbacks, it might be anticipated that in years in which the larger whales were present in small numbers the percentage of humpbacks would sensibly rise. In table "A," referring to South Georgia, the fall in the catch of humpbacks is obvious in the last five seasons. The smallest actual number (2,542) caught of the three species occurred in 1913-14, when the percentage of humpbacks was 18·6 (table "B"). The years on either side of this yielded about 4,000 whales each, but in the earlier year (1912-13) the percentage of humpbacks was 53·8, and in the later year (1914-15) it was only 15·6. 1915-16, almost the best year recorded (5,510 whales) had a percentage of 22·9 for the humpbacks and 1916-17, a much poorer year (3,600 whales) had a percentage of 9·3, the lowest recorded for the humpback. It is thus established that the percentage catch of humpbacks has not increased during years when, it may be presumed, the whalers caught everything they could successfully hunt.

The evidence from the African coasts is less complete, but there is reason to believe that a substantial reduction in the number of humpbacks has occurred here too. Thus, in the evidence given by Mr. C. O. Johnson, Director of the Southern Whaling and Sealing Company, Limited, before the Interdepartmental Committee on Whaling, on 30th April, 1914, it was stated that at Port Alexandra, South West Africa, all the whales are "trek whales," that is, whales coming from the southern ice-barrier and going north towards the French Congo, ninety-seven per cent. of the whales caught at this station being humpbacks. It is further known that of 799 whales caught by Natal companies during 1912, no less than 770 belonged to the same species. Five years later (1917) three whaling companies operating off the coast of Cape Colony, in much the same latitude, caught 1,049 whales, of which only 10 were humpbacks.*

* From statistics received at the British Museum, showing that nearly fifty per cent. of the total catch consisted of blue whales, while nearly forty per cent. were fin whales; the actual figures being: total catch, 1,049; blue whales, 509; fin whales, 416; humpbacks, 10; sei whales, 55; right whales, 2; sperm whales, 57.

The falling off in the number of humpbacks can also be inferred from the returns of whaling at the South Shetlands. During the season 1915-1916, 4,431 whales were caught at this locality, of which 1,845 were blue whales, 2,358 were fin whales, and only 219 were humpbacks; the small number of humpbacks now occurring in this locality having been specially remarked.

It has been maintained that this diminution is more apparent than real, that the humpback is easily frightened away from districts where it is hunted, and that vast numbers occur in other districts of the ocean. It is highly desirable that actual evidence should be obtained on this point; and the attention of the naturalists of the proposed expedition may well be directed to it.

It has been shown above that there are valid reasons for believing that the humpback migrates northwards after leaving the sub-Antarctic whaling grounds. It can hardly be doubted that a large proportion of those which have been killed, farther north, during recent years, have come from feeding grounds in some part of the Antarctic area; and the conclusion seems inevitable that the humpback schools have been decimated both on their feeding grounds in the far south during the southern summer, and on their breeding grounds in warmer water during other parts of the year. It would be in the highest degree unsafe to ignore the probability that destruction thus carried out can be without material effect on the total stock of southern humpbacks; and the conditions under which whaling has been conducted, in various localities, would appear to be well adapted for the rapid extermination of the humpback, or at least for the reduction of the numbers which frequent the whaling grounds to such an extent that its pursuit must cease to be profitable.

There is perhaps not sufficient evidence that the numbers of fin whales and blue whales have been materially reduced at present; and it may be hoped that with prudent management anything like extermination will be avoided.

4.—Reduction in the Number of Whales in Other Localities.

It may be stated in general terms that, prior to the commencement of intensive sub-Antarctic whaling, whaling operations have followed one invariable course, in whatever part of the world they have been carried out:—a period of great plenty, followed sooner or later by a diminution, usually coming on quickly (as in the case of the southern humpbacks), and culminating in a total cessation of whaling operations. Particular attention may be directed to the well known cases of the Greenland right whale (*Balæna mysticetus*) and the Pacific grey whale (*Rhachianectes glaucus*), as indicated below.

It must be remembered that the destructive power of the older whaling vessels was far inferior to that of modern whalers fitted with guns and harpoons carrying explosive charges. If the older type of vessel could accomplish something nearly approaching extermination, it must be obvious that modern whaling is likely to produce the same result in a far shorter period of time.

The following facts may be noticed:—

(*a*) *Atlantic Right Whale, Biscay Whale, or Nordkaper.*—The hunting of this whale is known to have commenced in the northern hemisphere at least a thousand years ago in the Bay of Biscay. It culminated in the sixteenth century, and only stopped short of actual extinction through the discovery of the Greenland whale (R. C. Andrews, 1916, page 296). The species then dropped out of sight and was supposed to be extinct; but, "although it appeared again a hundred years later, it has never recovered from the effects of its early persecution."

With regard to the southern right whale, it may be pointed out that it was once abundant in various localities in the southern seas, and that the numbers now caught are quite unimportant compared with those that were formerly obtained.

(*b*) *Greenland Whale.*—In 1607, according to Scoresby, this animal was found in immense numbers throughout the bays of the whole extent of the coast of Spitsbergen. It was not long before the whales left the bays as a result of whaling operations, and it became necessary for the whalers to follow them to the open sea. By the early part of the eighteenth century the captures of the Greenland whale were declining in the Spitsbergen Sea; and the whalers were turning their attention to Davis Strait, where the industry had for a time a highly profitable period. This region remained the principal hunting ground for whales for another hundred years, until here, too, the numbers began to decline; and whaling has practically ceased to exist in Davis Strait. A third period of prosperity in the history of the Greenland whale was inaugurated by its discovery in the North Pacific and the adjacent parts of the Arctic Ocean, where American whalers followed this animal for some years

with success. This industry declined in its turn; and, although one or two Greenland whales have been caught during the last year or two, the industry is practically extinct in all three of the districts where the species was formerly abundant. There is, moreover, no reason to suppose that this animal has made any substantial recovery in number even in the districts where it has remained longest unmolested.

(*c*) *Pacific Grey Whale* (*Rhachianectes glaucus*).—Some fifty years ago this species appeared regularly, at certain times in the year, along the Pacific coast of North America, in the course of its progress to or from the shallow water of the Californian lagoons, where it brought forth its young. The "fishery" did not last long, continual slaughter on the breeding-grounds depleting its numbers, so that the whaling stations were obliged to discontinue operations. For twenty years the species had been lost to science, and naturalists believed it to be extinct (R. C. Andrews, 1916, page 187). It has been ascertained, however, by Andrews that a regular fishery for this species is carried on by the Japanese on the south-east coast of Korea; although there is apparently no record of its re-appearance on the American coasts where it was formerly so abundant.

(*d*) *Rorqual Fishery in Newfoundland.*—The first whaling station in which modern methods were adopted was established in 1897. In the ten years, 1898-1907, some 4,000 whales were captured; but, while in 1903 three steamers took an average of 286 each, in 1905 fifteen steamers took only 59 each. The industry has steadily declined and the smaller companies have been ruined (R. C. Andrews, 1916, pages 298, 299).

(*e*) *Rorqual Fishery in Finmark.*—According to the account which has been given by Dr. J. Hjort (1902*), Svend Foyn commenced operations in the Varanger Fjord, with modern methods, in 1865. With the exhaustion of the stations first worked the whaling moved progressively westwards. In 1886 and 1887, thirty-four ships were operating—the highest number reached at any time; and after those years the number declined. The species hunted were the blue whale, the fin whale, the sei whale and the humpback. The whole whaling fleet obtained only about half the number of blue whales from the entire Finmark Sea, during the later years, that Svend Foyn caught in the sixties in the Varanger Fjord alone. Whaling has ceased in this region, although its discontinuance was due partly to considerations connected with the fishing industry.

(*f*) *White Whale* (*Delphinapterus leucas*).—This species occurred in hundreds off Spitsbergen in 1868, and it was much hunted from 1869 to 1878. Very few now occur in those waters, although they are still found plentifully to the north of Siberia. It is pointed out that if they have been exterminated in a locality none come back afterwards, for a time at least (Hjort, 1902, page 192).

(*g*) *Sperm Whale* (*Physeter catodon*).—Although this species still occurs in considerable numbers, in various localities, the areas where it is found are known to have experienced a very marked reduction in size; and there can be no question that the species is far less abundant than was formerly the case. The diminution has probably been little influenced, however, by what has taken place in the Dependencies, since the individuals there caught are stragglers of a species which has its headquarters in tropical and sub-tropical seas, where the hunting has occurred which has led to its reduction.

These instances will suffice to show that there is a strong *prima facie* reason for believing that unrestricted whaling is capable of reducing the numbers of the species hunted almost to vanishing point. Attention has repeatedly been called to the fact that when a species has been exterminated in a locality it does not as a rule re-appear in the same place, even after the cessation of whaling. Andrews states† that in all parts of the world the humpback and the blue whale are the first to succumb; while the fin whale and the sei whale will remain longer than any others. It must further be remembered that although certain species, such as the Greenland whale, remained plentiful throughout long periods during which every effort was made to capture them, this persistence may be ascribed to the fact that the methods of hunting then in use were far less efficient than those which are adopted in modern whaling. The use of Svend Foyn's harpoon-gun, and the other improvements introduced as the result of that invention, have entirely revolutionized the hunting of whales. It can hardly be doubted that modern methods are capable

* Hjort, J. "Fiskeri og Hvalfangst i det nordlige Norge," Aarsberetning vedk. Norges Fiskerier for 1902, 1ste Hefte, Bergen, 1902, page 180.

† Andrews, R. C., 1916, page 185.

of producing results far more serious than those which were universally used even beyond the middle of the nineteenth century.

5.—Food of Whales.

(See below, under *Migration of Whales*).

6.—Migration of Whales.

There can be no question that whales are migratory animals, though much remains to be found out with regard to the objects and the routes of their wanderings, which do not appear to be entirely regulated by the presence of food. This is shown by the fact that whales seek the warmer waters at certain times, and it is known that the surface-layers in these waters are relatively poor in plankton. There is reason for believing that their migrations are determined by several causes, of which the following seem to be most important: (i) temperature; (ii) the distribution of food; (iii) breeding.

(*a*) *Migration as affected by temperature.*—The possession of a thick covering of subcutaneous blubber renders the whales to a large extent independent of changes of temperature in the water; and they are able to maintain the high bodily temperature which is a necessity to them, as to other mammals, even in the icy waters of the Polar seas. Some of the species show, indeed, a definite preference for cold water, and are known to spend most of their lives near the edges of the Polar ice-fields. The blue whale is a species which is said to have a marked preference for the neighbourhood of ice. But even in species with this habit it is obvious that some of their movements are dependent on temperature, since they cannot breathe without coming to the surface, and they must necessarily move away from the Poles as the ice increases its extent with the approach of winter. Other species prefer warmer water; and the sperm whale may be regarded as normally an inhabitant of warmer seas, although occasional stragglers may be found from time to time even as far south as the South Shetlands. It is probable that the occurrence of sperm whales so far south is dependent on suitable conditions of temperature.

(*b*) *Feeding Migrations.*—The distribution of whales during a large part of the year may be assumed to be regulated by the necessity of finding regions productive of a sufficient supply of food to give nourishment to their enormous bodies; though it does not follow that they are at all times limited to parts of the ocean where food is plentiful. The sperm whale (a toothed whale) differs from the other species which are of practical importance in the Dependencies in feeding principally on cuttlefish, a diet varied with ordinary fishes; and it no doubt has to seize the animals on which it feeds individually, or one at a time. The other species in question belong to the group of whalebone whales, all of which feed by swimming through the water with open mouths, and straining off any food which happens to be in the water by means of the two series of whalebone-plates which are borne by the bones of the upper jaw. Although certain species, for instance the fin whale and the humpback, may consume large numbers of fishes, such as herrings, the typical food of this group consists of "plankton," a name given to the floating fauna and flora of the sea, mostly composed of animals and plants of small or even microscopic size. Although this method of feeding does not appear to give much opportunity for the selection of particular organisms, among a mixed assemblage present in the water, certain constituents of the plankton have a predominant influence on the migrations of whalebone whales. The waters of the Antarctic Ocean are known to produce enormous quantities of certain small Crustacea, which are referred to by the whalers as "shrimps," or by the Norwegian name of "kril." The occurrence of this plentiful supply of whale-food is undoubtedly the attraction which draws the whales to the Polar seas. The blue whale and the sei whale are believed to feed almost exclusively on small Crustacea; and it appears probable that even the fin whale and the humpback, which in other waters subsist largely on fishes, such as herring and capelan, feed mainly on "kril" during their sojourn in the waters of the far south.

The occurrence of "kril" depends on the season of the year. It is least abundant during the winter, but with the approach of spring it increases largely in amount, falling off again in the autumn. The Crustacea in question are necessarily dependent on finding the food on which they themselves subsist; and their ultimate food-supply actually consists of the chlorophyll-containing vegetable-organisms of the plankton, and probably mainly of diatoms, microscopic plants which are known to occur in prodigious numbers in the Polar seas. The processes by which green plants build up their protoplasm from the simpler substances

found in solution in the water can only take place in sunlight, and the diminution of the quantity of plankton during the winter months is no doubt due principally to the absence of light. The temperature and the salinity of the water are, however, factors which have an important influence on the growth of the plankton; and the study of the hydrography of the waters of the Dependencies is thus seen to be of the greatest importance for the comprehension of the conditions on which the provision of the whale-food depends.

There is much evidence to show how greatly the whales benefit by their visits to sub-Antarctic waters. These animals are frequently observed to arrive on the whaling grounds in poor condition, and with a comparatively thin layer of blubber. This state of affairs is altered as they commence to feed on the Antarctic "kril," and they then rapidly become fat and increase the quantity of their oil, and with it the thickness of their blubber. There is evidence, on the other hand, that the fat whales which leave the rich feeding grounds of the south become deficient in oil after a sojourn in Equatorial waters, where food is less abundant. In describing his experiences with the grey whale on the coast of Korea, Andrews (1916, page 207) points out that this species apparently takes no food while migrating, but, like fur-seals, is able to subsist on its own reserves for long periods. When it arrives on the Korean coast, during its northward migration, its blubber contains much less oil than is the case on its southward journey.

The occurrence of a plentiful food-supply in certain places does not, however, furnish a complete explanation of the migrations of whales. Thus it appears that in the far south the humpback, the fin whale, and the blue whale have much the same feeding habits; and if migration were entirely dependent on food they might all be expected to reach the feeding grounds and to leave them at almost the same times. The examination of the recorded facts shows that this is not the case. Although the occurrences of the several species are not identical from year to year, as might indeed be anticipated from the fact that the climatic conditions of succeeding years are not the same, certain broad facts emerge from the study of the records of a series of years. In the waters off South Georgia the humpback has usually been most abundant during November, December, and January. The fin whale has been captured in the largest numbers, in the same locality, during December; the catch in November and January having usually been markedly inferior to that in December; while there is an indication of a secondary maximum in March and April, after a short period during which the catch has appreciably lessened. The blue whale has been most frequent off South Georgia in January and February. Off the South Shetlands the occurrences have not been identical with those above indicated. The records of humpbacks at this locality are not sufficiently numerous to enable any generalization to be made; but the fin whale seems to reach its normal maximum in February, or at about the time when there is a falling off in the numbers near South Georgia; while the maximum frequency of the blue whale appears to occur in January. These differences are enough to show that each species has its own special habits, and may forsake a particular locality at times when the other species continue to find a sufficient supply of food there, but the causes of the different behaviour of the three species are obscure.

(c) Breeding migrations.

(i) *Pacific Grey Whale* (*Rhachianectes glaucus*).—According to Andrews (1916, page 202), the annual migration of this species occurs "as regularly as the seasons." . . . "On both sides of the Pacific the migrations take place almost at the same time. Along the Korean coast near the end of November single pregnant females appear, travelling steadily southward; a little later both males and females are seen; and finally only males bring up the rear; all having passed by January 25th."

"When going south almost every female is found to be carrying young nearly ready for birth, and all are hurrying straight ahead as though anxious to arrive at the breeding grounds as soon as possible. The devilfish again pass Ulsan, Korea, on the northward trip, about the middle of March, and by May 15th have disappeared."

On the Californian coast the cows entered the lagoons to bring forth their young between November and May. It is believed that they feed principally in the far north, and they are said to congregate in the Arctic Ocean and the Sea of Okhotsk during the summer.

(ii) *Humpback* (*Megaptera nodosa*).—The best evidence on the subject of the humpback is derivable from the experience of whalers in the northern seas and

off the east and west coast of Africa in the south, as summarized in important papers by Risting (1912) and Olsen (1914-15). Risting states quite definitely that "the humpback's migrations, both north and south of the equator, are divisible into a feeding migration towards the Polar regions and a breeding migration towards the warmer seas." These migrations are so constant and regular that "if the whalers have found a station from which it can be hunted on its course it is easier to shoot down and exterminate than any of the other species."

It is further asserted by the same author that, on its way to the breeding grounds "the humpback is not out in order to seek food, and it moves away therefore with great speed, at the same time keeping close to the land." It may thus be the case that there are certain seasons when whales are indifferent to the presence of food in large quantities, and that they may journey to or from their breeding resorts along routes which are not specially prolific in food. In the north the humpback migrates westwards along the Finmark coast in the months of February and March, coming from the east sea, in the open parts of which it must have passed the winter. The females have large fœtuses, which are almost ready to be born. "The object of this migration must therefore clearly be to seek warmer seas where the young can be born." Parturition and pairing take place in warmer seas; and humpbacks are found along the coast of North West Africa in April and May, the females being followed by the newly-born young. On their northward run they pass the whaling stations at the Hebrides and the Faroes, and are found off the Finmark coast from June to August. When the water becomes colder, in the autumn, the humpback moves northwards into the more eastern parts of the Northern Sea, where it usually passes the winter, feeding partly, as it appears, on herring. A similar migration occurs on the American side of the Atlantic; the humpback being abundant in the Greenland Sea during the summer and early autumn.

According to Risting the plankton on which whales feed becomes abundant in Antarctic seas during November, and "this food is carried by the currents towards the coasts of the great south Polar island groups." The humpback now puts in an appearance, being at first lean; but, as the summer advances, becoming rapidly fatter and fatter, its blubber being specially thick from February to April, as the result of the bountiful supply of food it has found in Antarctic waters. When the southern autumn arrives, and the food of the surface-waters decreases in amount, "the humpback proceeds northwards in order to seek warmer water, where the young can be born and where the pairing can happen." The females caught in the summer off South Georgia and the South Shetlands are nearly all pregnant. When the humpback wanders northwards it is extremely fat. It proceeds towards the great continents, and is found from the middle of May, or even earlier, moving northwards along the coasts of South America and Africa. The migration from the south lasts till the end of July, and the humpbacks go even north of the Equator. Towards the end of August the southward migration along the same coasts commences, but lasts until far in November; the animals being noticeably leaner, the females having cast their young and pairing having taken place. Similar movements take place in the Pacific on both sides of the equator; and the humpback is stated to migrate from the feeding grounds of the far south northwards along the coasts of Australia and the various island groups of this ocean.

Olsen states that the humpbacks arrive off South Africa during May, but most of them strike the coast farther north and do not touch the southern extremity of Africa when migrating. Along the east coast, where the warm Mozambique current flows southward to the south coast, humpbacks occasionally give birth to their young, but such whales are said to have continued the northward journey, accompanied by their new-born calves. If this observation is correct, it would appear that the northward migration is not entirely due to the necessities of parturition, but it may imply that impregnation occurs farther north, or that the calves flourish best in warm water. Olsen states that at the breeding places off Portuguese West and East Africa the first humpbacks arrive at the beginning of June, but the majority appear about the middle of July. Parturition occurs on the breeding grounds, and humpback-pairs, accompanied by their calves, later undertake the southward migration, appearing, on this journey, off Port Alexandra (Angola) as early as the end of August. The majority have left the African coast by October. Olsen believes that females are pregnant annually, and that impregnation takes place about four weeks after parturition.

A certain amount of evidence with regard to the migration of individual whales has been afforded by the recovery of lost harpoons. Olsen mentions two such cases, in one of which a harpoon which had been fixed in a humpback off Durban (latitude 29° 50′) in August was recovered later in latitude 23° 30′; and in another whale of the same species a harpoon lost in latitude 16° 20′ S., was recovered in November, two or three months later, off Durban.

It may be admitted that the facts here indicated give no precise information with regard to the migrations of the humpbacks which individually frequent the waters of the Dependencies. But to anyone who has studied the migrations of other animals it will appear clear that if in other localities humpbacks make an annual migration to warmer waters in the direction of the equator, and afterwards return to their feeding grounds near the poles, it may be anticipated with complete confidence that those of South Georgia and the South Shetlands will be found to have similar habits.

A further confirmation of the general results just indicated is given by statements which have been made by the Commander of H.M.S. "Dwarf."

According to the statements of Mr. D. G. Lillie,* referring to the opposite side of the Antarctic Ocean, the humpbacks of the far south migrate northwards at the beginning of winter into the warm seas in the neighbourhood of New Zealand and Norfolk Island. They pass New Zealand, on their northward run, from the middle of April to the end of August, but principally during May and the early part of June. About the middle of September they are to be seen in the same locality migrating south, on their way back to the Antarctic Ocean, most of them passing during October, while by the middle of December they are all to the south of New Zealand. Mr. Lillie is of opinion that the northward journey is a breeding migration.

(iii) *Rorquals and other Whales.*—With regard to these species, little information is at present available for southern specimens. The fin whale in northern waters is said to have less definitely marked migrations than the humpback, its movements being principally determined by the food-supply, and having little reference to breeding. There is some reason to believe, however, that fin whales migrate northwards in the spring and southwards in the autumn, like other species. Having a marked taste for a fish-diet, it thus follows the shoals of herring or capelan which frequent the northern waters where it is found. There seems to be little if any evidence that fin whales eat fishes to any great extent in the far south: and, so far as is known, they subsist mainly on "kril," and thus have the same feeding habits as blue whales and humpbacks.

Northern blue whales are said to spend a large portion of each year in migrating. They move, in the early spring, from the temperate or sub-tropical waters off the North American coast, travelling in a north-easterly direction to the Arctic Ocean, where they spend the summer. In autumn they pass towards the west and south. In the course of these migrations they proceed the coasts of Finmark, the Shetlands and Hebrides, and Ireland, making their appearance in various places at more or less definite seasons, when they are, or have been, hunted. In the south, the blue whale is said to be an ice-loving species, but this can hardly be taken to mean that it spends its whole life in the neighbourhood of the ice. It may merely imply that, while in the Antarctic seas, it follows the edge of the ice more closely than other species do. But the occurrence of blue whales on the African coasts is alone sufficient to show that these animals are not always in the neighbourhood of the ice.

Direct proof of migration is afforded by the recovery of harpoons of known origin from the bodies of animals captured in localities distant from those where the harpoons had struck them.

From the evidence recorded by Professor D'Arcy W. Thompson (1918), on the results of the operations of the Scottish whaling stations, it appears that right whales have been caught most frequently in June, and sperm whales in August, and the occurrence of these species at particular seasons in a given locality implies a migration of some sort.

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* British Antarctic ("Terra Nova") Expedition, 1910, Natural History Report, Zoology, Vol. I., No. 3, page 110 (British Museum, 1915).

It seems probable that all the large whales which are of practical importance in the Dependencies will be found to undertake annual migrations, which are in general towards the Pole in the spring, and towards the equator in the autumn. An extensive migration of this sort may be said to be known in the case of the humpback, while the facts are much less definitely ascertained with regard to the other species.

7.—Pairing, Gestation, Rate of Growth, and Length of Life.

These are all subjects on which further information is specially required, but on which it is well not to be too dogmatic. The general tendency of recent observations seems to indicate that sexual maturity is reached in a very small number of years from birth. It has been stated by Guldberg that the newly-born young of Cetacea has a length not less than one-quarter of that of the mother (or of the average length of fertile females), and usually rather more. In the gigantic blue whale, which may apparently reach a length of 100 feet, fœtuses of at least 23 feet have been recorded.

According to the excellent account of the Pacific grey whale which has recently been given by Andrews,* the fully grown animals reach a length of 45 feet. The length at birth is from 12 to 17 feet. The calves are born towards the end of December, and are about 25 feet long when they reach the Korean coast; indicating a growth of 9-10 feet in a little less than three months. Accepting 14 feet as the average length at birth, Andrews considers himself justified in stating that an increase of 18 feet in length—up to 32 feet—can be definitely asserted to take place in rather less than one year.

Dr. Hjort, an authority of much experience in these matters, is also of the opinion that the growth of the young whale takes place at a rapid rate after birth. In the evidence given by him on 7th May, 1914, he mentioned a recently-born young whale, probably a fin whale, which was observed off the Finmark coast in May, in the company of its mother. It had been attacked, and a hole made in its back, by which it was recognizable. This individual was noticed by the whalers all through the summer; and in the autumn it had a length of between 40 and 50 feet. Although its length at birth was not recorded, this can hardly have been much above 20 feet; and, in any case, a remarkably rapid rate of growth for these few months is indicated. A similar conclusion can be drawn from the observation of young whales, still sucking, of as much as 40 or 50 feet in length.

There is no conclusive evidence to show how many years are required to reach the full size of the species; nor can it be stated how many years a whale normally lives.

Opinions are divided with regard to the question whether gestation takes place annually or not, after sexual maturity is reached. If Risting's statement, quoted under section 6 (*c*), that the female humpbacks caught in sub-Antarctic waters are nearly all pregnant, is correct, it is difficult to avoid the conclusion that the pregnancy is annual. But the opinion is commonly expressed that some of the larger whales are pregnant only in alternate years.

The duration of gestation in the large whales is generally regarded as uncertain, though most authorities accept a period of twelve months, more or less. It is often stated that, in the case of certain species, no definite breeding season exists. This conclusion is based on the admitted fact that the recorded lengths of fœtal specimens obtained simultaneously from different females vary between wide limits, and that there does not appear to be a completely regular, progressive increase in the size of the fœtus as the season advances.

Very few direct observations are available with regard to pairing, the essential act in the process of breeding, as to either the seasons or the localities in which it occurs. In the absence of direct evidence, the most trustworthy conclusions seem to be those derivable from the statistical returns of fœtal specimens which have been furnished by the whaling companies to the British Museum (Natural History). These returns are by no means complete, and it cannot be doubted that the measurements of the fœtuses have, in many cases, been made roughly, and have sometimes been inaccurately entered in the forms supplied. An estimation of their accuracy has been made, however, by means of a careful comparison of the whalers' returns, mostly from South Georgia, with the records scattered in literature of fœtal specimens obtained in various localities in the

* Andrews, R.C., "Monographs of the Pacific Cetacea: I.—The California Grey Whale (*Rhachianectes Glaucus* Cope)," *Mem. Amer. Mus. Nat. Hist.* (*N.S.*), Vol. I., Part V., 1914, page 237, etc.

northern hemisphere. The result of this comparison has been to demonstrate a conformity between the southern and the northern records which is too striking to be interpreted as an accidental coincidence. The agreement would hardly exist if both sets of statistics were not in the main correct. In order to obtain this conformity it is necessary to assume that the breeding seasons of the south and the north are, roughly, six months apart—an assumption which is in itself inherently probable. The following are some of the more definite results obtained by a study of the statistics.

(*a*) On dividing the fin whale fœtuses into a series of classes differing by 2 feet in length (0-2 feet, 3-4 feet, 5-6 feet, and so on), and plotting out the numbers for the several classes expressed as percentages of the total number, it is found that the graphs or curves so obtained are regular ones, closely agreeing for the two hemispheres, and in both halves of the world rising from 0-2 feet to 5-6 feet, thence falling steeply to 19-20 feet.

(*b*) December in the south, and July in the north are the months which show the largest numbers of fœtal records of all sizes, these being months during which fin whales have been caught in specially large numbers in the two hemispheres respectively.

(*c*) On estimating the percentage frequency of the fœtal classes in the several months of the year, it is found that December in the south, and July in the north, have more fœtuses of 5-6 feet in length than those of any other size. These three results seem to indicate some definite relation between fœtuses of 5-6 feet in length, and the two months December and July, in the respective hemispheres. If pairing took place with equal frequency in all months of the year there would appear to be no reason for the predominance of a single class of fœtal lengths in any month, and it would be anticipated, on the contrary, that in each month during which fœtuses are recorded the several classes would be approximately equal in number. That this is not the case is in itself a strong reason for believing that the fin whale has a more or less definite breeding season. If it takes five months, for instance, from the date of impregnation, for a fœtus to reach the length of 5-6 feet, a period of maximum frequency of pairings during July (southern specimens) and February (northern specimens) would result in a corresponding frequency of fœtuses of those lengths during December and July, respectively, in the two hemispheres.

The conclusion that in each hemisphere there is a definite period during which pairing occurs with maximum frequency is further supported by an analysis of the fœtal records for each month of the whaling season. On reducing these numbers to percentages a definite predominance of the fœtuses of a certain length is shown for each month which possesses a sufficiently large number of records to make it probable that the result is normal. In the subjoined table each insertion of the limits of length of a fœtal class indicates that that class exhibits a definite predominance for the respective month.

Southern.		Northern.	
Months.	Fœtal Classes.	Months.	Fœtal Classes.
October	0 feet to 2 feet	April	0 feet to 2 feet
November	3 „ „ 4 „	May	3 „ „ 4 „
December	5 „ „ 6 „	June	3 „ „ 4 „
January	7 „ „ 8 „	July	5 „ „ 6 „
February	9 „ „ 10 „	August	5 „ „ 6 „
March	11 „ „ 12 „		7 „ „ 8 „

December and July, respectively, are thus not peculiar in showing a predominance of one fœtal class over all the others, and the figures further show that in the south at least there is evidence of a regular rate of increase of about 2 feet in each month of the principal whaling season. There appears to be some retardation of the growth, during the corresponding months, of northern fœtuses as compared with those of the south.

The figures for the blue whale are less demonstrative, but they are consistent with the view that a definite breeding season occurs in this species also, but that it is spread over a longer period than that of the fin whale, or, in other words, that

the impregnation-curve of the blue whale is lower and less steep than that of the fin whale.

The records for the humpback are less numerous, and their most marked feature is the occurrence of a specially large number of small fœtuses (0-2 feet) in the earlier months of the whaling seasons in the two hemispheres, indicating that the principal pairing period is less distant from October and April, respectively, than in the other two species.

The number of weeks or months required for the growth of the fœtus from 0 to 2 feet is at present unknown, and this involves some uncertainty in the estimation of the age of a fœtus of any given length. It must further be pointed out that the statistics can only be used on the assumption of a regular rate of increase in all the fœtuses, although the variability in length which no doubt occurs among the fœtuses of any given age is probably not sufficient to modify substantially the results based on the study of the smaller fœtuses at least. The estimation of age is thus difficult, and it has not appeared possible to do more than make a guess at the length of the period required for the growth up to 2 feet in length; while it has been necessary to leave out of account the probable variability in the length of fœtuses of the same age. The conclusion has, however, been provisionally reached that the principal pairing period, for the three species, falls in or near the months indicated in the subjoined table.

Species.	Southern.	Northern
Humpback	September	April.
Fin whale	July	January—February.
Blue whale	July—August	February.

Restricting the consideration of this question to southern whales, it follows, if the above conclusions are correct, that the principal breeding period occurs in months during which no large amount of whaling is done, in all three species; though it is admitted that pairing may occur, in a small number of cases, during most of the months of the year. In the present state of our knowledge the whaling grounds would thus appear to have but slight importance as breeding localities, and it is necessary to look principally to other regions for evidence with regard to this important question.

There seem to be few direct observations to show what are the principal breeding grounds of the fin whale and of the blue whale, but in the case of the humpback the evidence is more definite. It is explicitly stated that humpbacks associated in pairs appear on the South African coast at the end of May, but that farther north, at the breeding places off Portuguese West and East Africa, they begin to arrive in June, though most of them appear about the middle of July. It is asserted that impregnation takes place off the African coasts, even as far north as the equator, and that the young are born in the same localities. There seems to be but little evidence on this subject from South America, but it appears to be probable that the southern humpback brings forth its young and is impregnated in the warmer water off the coasts of the great southern continents.

The length of the young at birth probably varies within somewhat wide limits. The largest fœtuses which have been recorded in the statistics furnished to the British Museum are:—Fin whale, 21 feet; blue whale, 29 feet; humpback, 15 feet; but in the case of the last species it may be noted that fœtuses of respectively 16 feet 5 inches and 16 feet 9 inches have been recorded off the African coast. It is probable that the majority of the births take place at a length not exceeding, or not greatly exceeding, those of the fœtuses indicated above, in the respective species.

The length of the period of gestation is not definitely known, but there is reason to believe that it does not normally exceed twelve months, in any of the species; and that it is not far short of that period in the fin whale and the blue whale at least, although the humpback may have a somewhat shorter period.

Birth of the young probably occurs mostly during the months from July to September or October in all three species; that is to say, during the period when the whales are not present in large numbers on the whaling grounds of the Dependencies. It is not known whether a breeding female is pregnant every year or not.

The average length of southern pregnant fin whales is about 70 feet; of blue whales, about 80 feet; and of humpbacks, probably somewhat less than 40 feet. Pregnant females of considerably smaller sizes, in all three species, have been recorded by the whaling companies.

The length of the period of lactation is unknown, but it probably lasts for several months, during which the calf increases greatly in size. It is generally believed by modern authorities that whales become sexually mature at a very early age, but the length of life is unknown.

8.—The Probable Effect of Whaling Operations on the Number of Whales.

Some of the evidence that whaling is capable of reducing the numbers of whales has already been given in section 4. It is maintained, however, by many of the whalers that the species may be left to look after their own interests, without the assistance of protective legislation, on the ground that when the number reaches a certain point whaling will cease to be profitable and will automatically come to an end. It is argued that this cessation of whaling will occur before the species have reached a dangerous degree of depletion; and that with the termination of whaling the animals will once more increase in number. It is suggested that the disastrous results of the persecution of the Greenland whale must not be taken as a fair criterion of what is likely to happen with other species. The Greenland whale has, individually, a value which far exceeds that of any other species; since, in addition to the quantity of oil it produces, its baleen or whalebone is present in large quantity, and has a high commercial value. So high a price was formerly realized by the sale of the products of this species that it was possible for one of the small whalers formerly employed to pay its expenses for the season if it had captured no more than a single Greenland whale. The chase of this species was accordingly possible even when whales had become very scarce. With the Antarctic whaling it is claimed that the conditions are different. The distances to be travelled are much greater, the vessels employed are larger and their expenses are higher, and the value of each whale caught is far less than that of a Greenland whale. The point when whaling ceases to be profitable will accordingly be reached long before there is any danger of the extermination of the whales hunted.

Another argument tending in the same direction has been developed by Dr. Hjort. While the Greenland whale had several foci of distribution, interrupted by the land-masses of the Arctic Ocean, the southern whales have an extensive area of distribution which is completely circumpolar. Many parts of this area are inaccessible; and it is claimed that there will always be considerable tracts of the Antarctic Ocean where the whales are safe from pursuit. The operations of the whalers in certain restricted regions will accordingly not be able to produce anything like an extermination of the complete stock of the Antarctic whales.

In commenting on the whalers' contention that the reduction in number of a species is of little importance because it may be expected to be reversed when whaling has ceased, it may be pointed out that the analogy of other cases does not support this view. I think it may safely be asserted that there is no case known in which a species of whale has been exterminated in any locality and has afterwards become common in that locality, even after a long interval during which the species has been immune from persecution. The Greenland whale, the Atlantic right whale, and the Pacific grey whale may be cited in this connexion. It is true that the last two of these species were for many years believed to be extinct, and have nevertheless re-appeared. But although so much may be conceded, it must be pointed out that the recovery has been only partial. A certain number of right whales are taken from time to time in the North Atlantic, but the once flourishing "fishery" of the Bay of Biscay has not been re-established. While the grey whale has been rediscovered off the Korean coast, there has been no possibility of resuscitating the American chase of this species in localities where it formerly abounded. The area of distribution of this species was the North Pacific—a sufficiently wide area, one would suppose, if great weight is to be attached to the argument that a wide distribution is likely to prevent the extermination of a species which is only hunted in a limited portion of its range. I do not know whether any Greenland whales still survive in the Greenland Sea, where they were once present in enormous numbers; but in any case there is no reason to suppose that they are anything but rare off the coasts of Spitsbergen, Jan Mayen, and East Greenland, though they have not been hunted in those districts for nearly a hundred years. Attention has already been called to the well-founded belief that when a species has been exterminated in

a given locality it does not return to the same place, even after long periods during which it could do so without being molested.

This last consideration has an important bearing on the future of whaling in the Dependencies of the Falkland Islands. Should the whales be driven from the present hunting grounds, there is reason to believe that the industry could not readily be re-established there, even after a period of complete rest. The financial prosperity of the present time would be a thing of the past; and the occurrence of whales in distant parts of the Antarctic Ocean would have no practical interest for South Georgia and the South Shetlands. This is, indeed, a legitimate answer to Dr. Hjort's argument based on the existence of a widely distributed Antarctic stock of whales. It is not necessary to dispute the correctness of that assumption. But there are already grave signs of a depletion of the stock of humpbacks; and the history of rorqual hunting on the northern coast of Norway and off Newfoundland shows that whaling is capable of producing serious effects even in such species as the fin whale and the blue whale. These are matters in which present prosperity is apt to induce those who are financially interested to take an unduly optimistic view. The Committee will probably be well advised if they proceed with caution, by regarding any evidence they may obtain of a marked reduction in the number of whales frequenting the districts with which they are concerned as a warning which it is not safe to disregard. The world hunt for whales "bids fair to end ere the close of the twentieth century" (Andrews, 1916, page 296).

9.—Investigations required.

The precise nature of the inquiries which it will be necessary to institute will probably become clearer as the result of preliminary investigations made on the spot; and anything that can be said at the present moment should be regarded as tentative and subject to modification with fuller knowledge. The following points may, however, be indicated as lines of inquiry which ought to prove profitable.

(*a*) *Species and Races of Whales.*—It is important to ascertain whether the whales of the far south are specifically identical with their northern representatives; and to investigate the question whether any species is represented in the area under consideration by distinct races. This ought to imply the collection of a considerable number of specimens. It may be remarked that it has been asserted that several distinct forms of humpback are distinguishable, and that the fin whale is also represented by more than a single race. The question whether *Balænoptera brydei*, recently described as a new species of rorqual occurring off the coast of South Africa, is really distinct requires further study.

(*b*) *Plankton.*—A systematic investigation is required of the plankton-organisms which constitute the food of whales. Further attention should be paid to the question what constituents of the plankton are most important from this point of view. The seasonal occurrence of these organisms should be determined, and the geographical limits within which they occur in abundance. The examination of the plankton should not be restricted to the whaling grounds, but should be carried out in other areas as well, particularly along the migration-routes of the whales. It should be ascertained, as far as possible, whether the lines of migration depend to any large extent on the occurrence of considerable quantities of plankton, or whether the whales select routes leading directly to their breeding-grounds independently of the presence of food during migration. The examination of the contents of the stomachs of whales would naturally form a part of this investigation, which might be expected to prove an arduous piece of work. Evidence should be obtained to show how far the copious development of the Antarctic plankton is dependent on sunlight, and whether the organisms in question are to be found during the dark days of winter.

(*c*) *Hydrography.*—Careful investigations will be required with regard to the temperature and salinity of the waters frequented by whales. These are factors which doubtless have a profound influence on the development of the plankton; and it is not impossible that the migration-routes of the whales may be directly related to temperature.

(*d*) *Migrations.*—No opportunity should be lost of obtaining accurate information with regard to the migration-routes of each of the important species. The statements which have been made about the humpback (see section 6) should be verified or corrected; and further observations should be made on the movements of the fin whale and of the blue whale. One method which has been suggested is to intercept the main migrations and actually to follow the wanderings of the whales in a ship. The evidence obtainable from finding old harpoons in captured whales

should be carefully collected and studied. A more systematic method of inquiry, by devising some means of marking individual whales, a proportion of which should be captured later, has been proposed by Dr. Hjort; and this suggestion appears to be well worth following up. I believe I am right in stating that the same idea had already occurred to the late Major Barrett-Hamilton at the time when he undertook his expedition to South Georgia in the autumn of 1913; but I am unable at the moment to find my authority for this statement.

Evidence already exists to show that in certain species of Cetacea the two sexes, or young and adult specimens, may associate in separate schools during migration. Thus the bottle-nosed whale (*Hyperoodon*) is commonly stranded on our own coasts during its autumnal southward migration; but it is asserted that the individuals thus found are almost always adult females, commonly accompanied by a calf, or immature specimens of either sex. The fully adult males of this species have hardly ever been recorded off the British coasts; and it is believed that this is because their migration-route lies so far out to sea that they do not come ashore while on their journeys. If it could be ascertained that the Antarctic whales associated in schools of separate sexes, or that young and adult individuals travelled in separate parties, at any period of the year, the information thus obtained might form a most important basis on which to found protective measures.

A careful correlation of the records from South Georgia and the South Shetlands with those from Africa and South America might give important indirect evidence with regard to migration. If it can be shown, for instance, that it is the rule for whales to become numerous on the African coasts at the season when they are disappearing from Antarctic seas, and *vice versa*, there will be strong presumptive evidence that the same herds have been observed in different phases of their migration. There is already a good deal of reason for believing that this is actually the case, with the humpback at least. For this reason it is highly desirable to obtain detailed statistics from the South Shetlands, the South Orkneys, Graham Land, Africa, and South America, of the kind already received by the British Museum from South Georgia. Whaling statistics from New Zealand and Australia might also contribute information of importance; and it need hardly be said that some knowledge of what is going on in Ross Sea is highly desirable. It may be added that steps have already been taken for obtaining these statistics from the South Shetlands, the South Orkneys, South Africa, New Zealand, and Australia.

(e) Breeding.—This subject requires investigation from every possible point of view. An observer who is to visit the whaling stations should receive some preliminary training with regard to the reproductive processes in Mammalia; and thus be in a position to interpret the evidence obtainable from the study of the *corpora lutea* of the ovaries, and from the indications of œstrus and lactation. Work in these directions was commenced by the late Major Barrett-Hamilton at South Georgia, and it may well lead to important practical results.

The work of a trained observer at the stations is also required in order to obtain the fullest possible information with regard to pregnancy and the length of every individual fœtus observed. The whaling statistics already received at the British Museum contain much valuable information on this subject; but they do not go nearly far enough. It cannot be doubted that the majority of the very small fœtuses are overlooked altogether and that a number of the females said not to be pregnant are really in an early stage of pregnancy. It is important to know what proportion of the females are actually pregnant; as bearing, for instance, on the question whether pregnancy occurs annually or not. There are, no doubt, very serious difficulties in finding a minute fœtus in the enormous bulk of the viscera of a large whale; but a skilled observer who is specially looking for evidence on this subject may be expected to have a larger measure of success than an official of a whaling company, who records this evidence only when it is forced on his notice, and cannot be expected to devote much of his time to making a methodical search.

With the acquisition of a large body of evidence relating to the occurrence of fœtuses, their individual lengths, and the dates of capture of the pregnant females, an important step might be made towards an accurate estimation of the duration of pregnancy and the probable dates of pairing. Results thus obtained should be checked by observations on the breeding-grounds of the association of sexually mature males and females, with, if possible, observation and recording of the actual process of pairing, of the dates of parturition and the localities where this occurs, of the occurrence of calves with nursing females, and of the increase in size of the calves during definite periods of time. It is obvious that if these observations are to be carried out satisfactorily the activities of the research staff must not be limited

to the waters in the neighbourhood of South Georgia, but must extend, in all probability, at least as far as the Equator, where the humpback is believed to breed. It may further be remarked that an accurate knowledge of the breeding of whales is of the highest importance as a basis for the protective measures which may be required. Close times for birds and other animals which it is desired to protect are almost always instituted with reference to the respective breeding seasons.

10.—Protective Measures.

This is the most difficult and the most controversial of the subjects considered in this memorandum. Considering the fact that there are already indications which it would be unwise to ignore of a serious reduction in the number of humpbacks, it is possible that an initial step might be taken with advantage by making an ordinance forbidding the capture of members of this species for a series of years. As the humpbacks at present constitute a relatively unimportant proportion of the total catch in sub-Antarctic waters, this prohibition would inflict a comparatively small injury in those localities on the whalers, who could continue to make their profits by the chase of the fin whale and the blue whale. But, on the other hand, it would be felt as a great hardship by companies operating on the coasts of Africa and in other districts where humpbacks constitute the major part of the catch, if any such districts still exist. The limitation of the activities of "floating factories," which are unable to utilize the greater part of the whale-carcasses, would also seem to be desirable, in order to avoid the enormous waste of material which at present occurs. If it were rendered obligatory to utilize the entire carcass, the number of whales killed would be reduced materially.

It appears to me to be undesirable to attempt to decide, at the present stage, what measures should ultimately be taken—a subject on which the Committee will presumably have to make recommendations when further information has been collected. But I feel it my duty to express my very strong opinion that in one way or another the slaughter of whales which is at present taking place must be checked, before many years have elapsed, if permanent injury is not to be done to the whales themselves and to the interests of the whaling companies.

I should like to add that I have derived much assistance, in drawing up this Memorandum, from a Report, at present unpublished, which was prepared for the Colonial Office by Mr. M. A. C. Hinton, on the observations made by the late Major G. E. H. Barrett-Hamilton at South Georgia in 1913-14.

S. F. HARMER.

British Museum (Natural History),
19th May, 1919.

APPENDIX IX.

MEMORANDUM OF INTERVIEW WITH THE RIGHT HONOURABLE LORD ROTHSCHILD.

1.—Whales.

Lord Rothschild stated that, although he had taken much interest in the study of whales, he did not profess to have the same knowledge of these animals as of seals. He was, however, of opinion that modern methods of whaling threatened to reduce the stock of whales, particularly the humpback, to a dangerously low point, and he considered that investigations should certainly be instituted into the breeding and migration of the different species. In particular it is very necessary to test the theory that the whales have definite breeding seasons. This theory is disputed, but personally he is convinced that a very large proportion of the females breed during certain months, which vary with the different species. Apparently migration is closely connected with breeding and has little to do with food, since it appears that when migrating the whales are in an emaciated condition and do not stop to feed. The result of such investigations may show that it is desirable to institute:—

(*a*) A temporary close time over the areas and during the periods in which the whales generally breed; and

(*b*) The prohibition of whaling by areas for terms of years.

With regard to (*a*), the breeding close season should coincide with the period in which the greater number of whales have their young, since the animals remain on the breeding ground until the calves are well grown. With regard to the difficulty that the areas in which the humpbacks are commonly supposed to breed (e.g., off the French Congo and Portuguese West Africa) lie outside British jurisdiction, Lord Rothschild presumed that it would be competent for the Committee

to recommend that, if the proposed investigation established the necessity for international action, steps should be taken to call an International Conference with a view to securing the co-operation of the foreign Governments concerned.

In order to give effect to suggestion (*b*) with the least disadvantage to the whaling industry, the Governments of those portions of the Empire from which whaling is carried on should agree to prohibit operations periodically for terms of two, three, or four years. If the stock of a particular species is alarmingly low, the prohibition should be made general over all the areas: but if a species is fairly plentiful the partial prohibition referred to should be sufficient.

All reports indicate that the humpback whales have seriously diminished everywhere, and the industry would apparently suffer little if the pursuit of this species were entirely prohibited for a period of years. In reply to the theory that the reduction in the number of humpbacks observed at South Georgia does not necessarily indicate a diminution in the stock of the species, but is possibly due to the animals being frightened from the whaling grounds, Lord Rothschild said that he generally found, throughout the whole of the zoological kingdom, that whenever naturalists have raised the question of the protection of any species the argument of retirement from particular areas has been brought forward. He did not consider that this argument had any sound basis in the case of whales or seals. Wherever intensive whaling has taken place the areas cleared have never recovered; and there is no evidence of a depleted area being repopulated from other areas. The Greenland whale affords the best proof to the contrary. Although whales have entire freedom of movement in the ocean, they evidently prefer certain definite areas of sea, and when driven from those areas it is necessary to proceed considerable distances before one finds any "patch of ground," as the whalers call it, where whales are found in any quantity. In every case the first sign of danger is that the size of the average specimens caught diminishes very largely. The recorded lengths of captured blue whales now rarely exceed ninety-five feet, although at one time specimens were taken over one hundred feet long. If, therefore, for example, only eighty feet specimens of the blue whale were being taken, it would show that serious depletion was taking place. The only whale in danger at the present moment is the humpback, the pursuit of which should be prohibited immediately, either wholly, or in certain areas, for a period of one or two years, until the proposed investigations are concluded. As regards the Southern whaling industry, it may be pointed out that operations have been carried on in three areas around the Antarctic (i.e., off the Cape, in Australasian waters, and in the waters of the Dependencies of the Falkland Islands). The resulting toll of whales is seriously disturbing.

As regards the limitation of licences, Lord Rothschild agreed that the present system of limiting the number of whale catchers to be used under each lease or licence is a beneficial measure; and he suggested that a limitation on the number of whales to be taken in each season would also have good effects. He also referred to the desirability of rigidly enforcing the prohibition against taking the female when accompanied by a calf.

Lord Rothschild said it was difficult to suggest any special means of studying the lines of migration, but a small and speedy boat might be attached to the proposed research vessel for the purpose of following up the whales when the migration begins. Marking whales by firing a small missile through the fluke or back fin would probably secure valuable information: but the services of a very expert gunner would obviously have to be retained for the purpose. As an alternative a mark might be shot into the blubber, but in that case it would be necessary to avoid penetration of the body of the whale.

2.—Elephant Seals.

The fact that elephant seals are at present extremely numerous in South Georgia might give rise to the idea that the animals are not in want of protection. Although there is no reason to suppose that the species is in danger, experience shows that extermination when it once starts is very rapid. In this connexion Lord Rothschild drew attention to the extermination of the elephant seals on Heard Island and off the coasts of Tasmania and Southern Australia. He also referred to the great reduction of these animals on Macquarie Island; and said that this had been accomplished in a very short period, so that it is necessary to watch most carefully the killing in South Georgia, so as to grant complete, or partial, protection in good time. As already stated, the first intimation of danger would be a very great reduction in the size of the seals, since, with

the taking of the finest specimens, the average size of the animals would tend to diminish. Some thirty-five years ago male elephant seals of twenty-three feet were very numerous at Kerguelen; since then herds have very seriously diminished, and it is doubtful whether bulls exceeding sixteen feet are now to be found. The existing regulations should be very strictly carried out, and if there is the least sign of the bulls diminishing in size the regulations should be still further strengthened. In addition, the migration of the animals should be carefully studied. The fact that the elephant seals have re-established themselves in South Georgia since 1885, when they were reported to be very few in number, points to the possibility of repopulation from the Crozet Islands.

As regards the suggestion that the system in operation at the Pribilof Islands of taking only the young bachelor fur seals might be adopted with advantage in the case of the elephant seals of South Georgia, Lord Rothschild pointed out that the fur seal is possessed of flippers of large size in comparison to its bulk, and is able to travel inland, only the young bachelors remaining on the beach; the elephant seal, on the other hand, cannot drag itself any distance, and animals of all ages and both sexes congregate together on the beach.

3.—Fur Seal.

It would be of great importance if the fur seal could be re-established in the Dependencies of the Falkland Islands, but in that case the stocks should be obtained from the rookeries south of the equator. The fur seal thrives in captivity and there should be no difficulty in transporting the specimens. The Cape fur seal would probably succeed best and be less likely to "home" than the specimens from the Lobos Islands, since they would be removed from their usual lines of migration. On the other hand, the Cape fur seal is a smaller animal and is less long-lived than other varieties.

4.—Acclimatization.

In connexion with the suggested introduction of the musquash, Lord Rothschild expressed himself as very strongly opposed to such a step on both zoological and practical grounds. In particular the introduction of rodents or any small carnivorous animals should on no account be permitted.

5.—Penguins.

Lord Rothschild said that, except perhaps as regards the King penguin, he did not consider the penguins of South Georgia were in any danger so long as the boiling down of the birds for oil was not permitted. Careful observation should, however, be made from time to time as to the numbers of the birds in the rookeries.

6.—General.

Finally, Lord Rothschild urged that, in the case of all species of animals found in the Dependencies, a strict observation should be kept and careful statistics recorded, so that any change in the numbers may be noted and protection afforded if found necessary. This is desirable, even in cases in which animals are abundant, since experience shows that where there is no apparent danger there is a tendency to relax vigilance.

December, 1918.

APPENDIX X.

MEMORANDUM OF INTERVIEW WITH Mr. T. E. SALVESEN, OF THE FIRM OF Messrs. CHR. SALVESEN, OF LEITH.

1.—Stock of Whales.

Mr. Salvesen expressed the view that the rate at which whales are being taken in South Georgia, one of the Dependencies of the Falkland Islands, has been in excess of the rate of production, with the result that the stock has been depleted. There is no doubt that whales are far fewer, and that excessive killing is taking place if it is desired to retain the industry permanently.

As regards the various species, the humpback, which comes closer to the land, is the easiest to catch. Speaking purely from a commercial, and not from a scientific, point of view, this animal has for all practical purposes been exterminated, since it is no longer a paying proposition to hunt the humpback alone. This has been shown by experience on the coast of Africa. It is a fallacy to suppose that the

humpbacks are frightened from the feeding grounds by whaling operations. There has been some diminution in the numbers of fin and blue whales at South Georgia; but there is no appreciable difference in the numbers observed at the South Shetlands, so far as ascertained. No hard and fast rule can be laid down from catch statistics as to whether a species is declining or not. The evidence generally goes to show that the numbers of the various species differ in each year; for example, in the first three weeks of the current season, commencing 1st October, 1918, practically all the whales taken at South Georgia were finbacks, whereas, in the corresponding period of the season 1917-18, the catch was almost entirely confined to blue whales. The total number of whales at South Georgia varies according to the climatic conditions. If the season be mild and the fast ice far south the catch at South Georgia will be reduced. On the other hand, if the weather is severe whales will be more plentiful. The southern whales do not go to the northern hemisphere, and if the stock were untouched, the same individuals would be found on the same feeding ground year by year, though whether the animals would be mainly found near to, or remote from, South Georgia would depend on the weather. The humpback is taken on every opportunity, since it is the easiest to catch; but the whalers naturally prefer to take the fin and blue whales, for which higher bonuses are paid. In the early years of the industry the catchers could only handle a fin and blue whale in very calm weather; but the introduction of larger boats and stronger gear has enabled the larger whales to be dealt with in late years. As regards the stock of whales in the ocean, reports have been received from time to time from ship captains of large numbers having been seen; but too much reliance should not be placed on such reports. No reports have come to hand of large numbers of humpbacks being seen in the open seas.

2.—Protective Measures.

The catch can be restricted in various ways, e.g., (1) by limiting the number of whale carcasses to be brought into each station, (2) by imposing a maximum on the amount of oil allowed to be produced, (3) by limiting the number of whale catchers employed. Of these, the last is the system at present in force. Mr. Salvesen recommended its continuance, and suggested, as regards South Georgia, that the number of catchers authorized should be reduced to sixteen or seventeen from twenty-one, the pre-War figure. It is impossible to say whether the lower figures suggested represent the maximum number which might safely be allowed to operate at South Georgia without detriment to the stock of whales; but obviously there will be less risk of extermination with the reduced number. As regards the South Shetlands, a decision as to the number of companies to be allowed to operate in future should be deferred until it is known how many of the pre-War companies will resume operations. Whaling should not again be allowed at the South Orkneys, a field which has been abandoned during the War. As regards other possible measures, it would be practicable to prohibit the taking of humpbacks, and there would be no serious objection on commercial grounds. The whalers have no difficulty in recognizing the species if the spout is visible; but, as Government representatives are not present on all the stations, it would be necessary to rely largely on the loyalty and good faith of the companies. The take of whales could also be reduced by imposing a close time during the winter months. This, however, would not have much effect, even at South Georgia, where, although whaling is carried on practically all the year round, the catch is mainly made in the summer months. In the winter, both the presence of ice and the severity of the weather interfere with operations at South Georgia. At the South Shetlands there is a natural close time, as whaling operations cease with the advent of winter owing to climatic conditions.

The prohibition of whaling at South Georgia during the winter months would not affect the companies materially from a financial point of view, provided the men can be got away from the Dependency. In this respect the British companies are at a disadvantage owing to the Board of Trade regulation that a doctor must be carried by any vessel conveying a hundred or more men.

3.—Preference to British Interests.

Apart from patriotic reasons, such preference is desirable for the benefit of the Imperial revenue, since the foreign companies, while they are very law-abiding and loyally observe the regulations, do not pay income tax or super tax. In this connexion Mr. Salvesen expressed the view that the British Government had paid insufficient attention to the claims of

British applicants, and that in some cases preference had been given to foreigners. Also his firm had not received from His Majesty's Government any assistance similar to that afforded to the Norwegian industry from the Government of that country. Mr. Salvesen agreed that the treatment of the whaling industry should follow the general policy of the Empire in regard to foreign trade interests; but as regards the possibility of retaliation in Norway, he pointed out that the Norwegian Government follows an exclusive policy, not merely as regards whaling facilities, but also in other directions.

4.—Utilization.

The floating factory is less efficient than a shore station. At the latter it is possible to convert the whole carcass into merchantable produce; but a floating factory cannot utilize every part of the carcass. For instance, it has been found impracticable to carry on board plant for the manufacture of guano. The floating factory has, however, the advantage of being able to move to the most favourable fishery grounds, and is, therefore, less dependent on climatic conditions than the shore stations at South Georgia. On the other hand, the production of a floating factory is limited to the carrying capacity of the vessel, while a shore station is not subject to any such limitation of output. Floating factories are chiefly used at the South Shetlands, where there is only one suitable site for a shore station. Even if practicable, the establishment of other shore stations in that Dependency would merely have the advantage of securing the utilization of the less important parts of the carcass which are at present wasted. In addition to the wastage due to the lack of facilities for producing fertilizers, the floating factory produces per whale about ten per cent. less oil than a shore station, since the parts of the animal, e.g., the flesh, which are less productive of oil, are not utilized. The plant required for the manufacture of fertilizers is elaborate, and the use of pontoons or hulks in this connexion at the South Shetlands would not be practicable, since the weather is too stormy to admit of their being towed south each season. If left at the Dependencies during the winter they would in all probability be smashed in the ice. At South Georgia most companies are required by their licences to utilize the whole carcass, and at all the shore stations, including those of the companies who are not under any such obligation, the necessary plant has been, or is being, installed. There is, even in the exceptional circumstances arising out of the War, little waste at South Georgia apart from the cessation of the manufacture of guano, which has become impracticable owing to high freight and the cost of coal. When normal conditions have returned it should be possible to manufacture guano at a profit. Owing to the need for oil during the War some relaxation of the regulations has been allowed, and the stations have been working with an increased catch of from twenty-five to fifty per cent., without, except in the case of Messrs. Salvesen's stations, any increase of plant. After the War the existing plant should be adequate to deal fully with the catch at all the stations.

5.—Post-War demand for Oil.

In view of the demand for edible fats there will be an ample market for whale oil after the War. The whaling industry was saved by the hydrogenating process, by which whale oil is converted into a product suitable for food purposes.

6.—Use of British Materials.

Foreign companies use foreign material almost entirely. They only come to this country for coal. On some occasions they have gone to Germany even for that commodity. Messrs. Salvesen have always endeavoured to use British materials; but the prejudices of British manufacturers have been a considerable difficulty in achieving this result. With the exception of wood, harpoons, points and fuses for harpoons, guns, and detonators for guns, the firm's equipment is now practically all British. Eight whale catchers have been built to the order of Messrs. Salvesen in this country, with the exception of the guns, which are obtained from Norway and Sweden, and a floating factory can now be completely equipped in this country; the s.s. "Neko," belonging to Messrs. Salvesen, was so equipped in 1911 in Leith. Whale lines and foregoers can also be obtained in the United Kingdom, but the inability to obtain Italian hemp has caused difficulties, as Manila hemp is not a suitable substitute, since it stiffens in the icy cold water.

7.—British Labour.

In Norway there is a whaling population, which is concentrated in the towns of Tönsberg, Sandefjord, and Larvik. In the United Kingdom,

however, men engaged for a whaling expedition are lost sight of after their return. In Japan there is a native population, but such is not the case in the Dependencies of the Falkland Islands. The British sailor offers better material, but he will not work under alien control. A British engineer on a whale catcher would have to be certificated, and such an engineer would not engage for such employment. Instruction would be expensive, since a whale catcher burns six tons of coal a day, at a cost of £12 to £14 per ton in South Georgia. It would be cheaper to use an instructional vessel in the Shetlands (North Britain). An expert gunner would be required for training purposes; he would have to be a Norwegian and be under control. It was suggested to Mr. Salvesen that the difficulty of alien control would be obviated by having a system of divided control similar to that obtaining on a fishery survey vessel. Under such an arrangement the gunner would only take control during the actual operation of taking a whale. As regards pay, before the War each man in a whale catcher would earn about twice as much as a British able seaman, but the rate varies with the success of the whaling operations, as the remuneration is partly by bonus. The bonus system has caused some little difficulty with the Sailors' and Firemen's Union in connexion with men already engaged in this country, but in Leith, Liverpool, and Glasgow the necessity for it has been recognized. Messrs. Salvesen's transport vessels are British-owned ships, and are not dependent on Norwegian labour. A British captain has been appointed master on their floating factory "Neko," and endeavours are being made to man the factory entirely by British labour. It is hoped that it will be possible to achieve this result in the course of the next few years. Mr. Salvesen, however, sees no prospect of working whale catchers with British labour.

8.—Survey.

A survey of the north side of South Georgia, and perhaps south-west coast also, is the most pressing need; but there are also on the south-east coast good harbours which might be surveyed. It has been suggested that, in the absence of a survey ship, one or two officers might conduct operations with facilities offering locally. Mr. Salvesen explained that his firm had an old whaler which was used in connexion with a geological expedition sent out by his firm. The vessel is ninety feet long over all and steams about nine knots. She could be used for survey purposes or for marking whales.

Accommodation for a survey party could be found at several whaling stations. The charts of the South Shetlands are very defective, but a survey of the South Orkneys is not of much importance from a whaling point of view.

9.—Wireless Communication.

Messrs. Salvesen have a large dynamo at South Georgia, which they desired to use for this purpose, but they were advised by the Colonial Office that the configuration of the island presented an obstacle. The firm had endeavoured to assist the Government in establishing wireless communication, but so far had not received any sympathetic response. Their vessels had received messages from Port Stanley, but had been unable to communicate with that port.

10.—New Regulations.

Mr. Salvesen emphasized the necessity of publishing any new regulations for the whaling season 1919-20 as early as possible, as arrangements would have to be made fully half a year ahead in order to apply them with a minimum of loss.

November, 1918.

APPENDIX XI.

MEMORANDUM OF INTERVIEW WITH CAPTAIN C. A. LARSEN AND CAPTAIN THORALF SÖRLLE REPRESENTATIVES OF THE NORWEGIAN UNION OF WHALING COMPANIES.

1.—Description of Industry.

(a) General.—The whales are taken by small steamers known as "catchers," the harpoon being shot into the whale from a cannon placed at the bow of the vessel. The catchers work in connexion with either a shore station or a floating factory, at which the carcasses are reduced. At South Georgia the operations are mainly carried on at shore stations, which provide facilities for the complete utilization of the carcasses. At the South Shetlands floating factories are mainly

used, there being only one suitable site—Deception Harbour—for a shore station. Elsewhere in the South Shetlands the harbours are unsuitable on account of the presence of ice.

(*b*) *Shore Stations.*—A shore station is equipped with open boilers for extracting the oil from the blubber, and with pressure boilers for dealing with the flensed carcasses. A fully equipped station is also provided with plant for the manufacture of guano. The total staff of workmen at a station at South Georgia comprises, as a rule, from one hundred and thirty to one hundred and fifty men. A list of the specially skilled grades is given in Annexure I.

(*c*) *Floating Factories.*—In view of the climatic conditions it is not possible to operate the floating factories in the open sea. The factories, therefore, work in convenient harbours. The carcasses are flensed alongside the vessels, which are provided with open and pressure boilers. Experiments in the use of plant for the manufacture of guano have not been attended with success, hence a certain amount of the carcass is necessarily wasted. The factories in use in the Dependencies of the Falkland Islands average 7,500 tons dead weight, and have a carrying capacity of from 5,000-7,000 tons of oil, which is conveyed either wholly or partly in tanks or barrels of 170 kilograms (six to the ton). To each factory three whale catchers are attached. Particulars of the crews of a floating factory and whale boat at the South Shetlands will be found in Annexure III.

(*d*) *Whale Catchers.*—The catchers are small steamers of from 150 to 180 tons gross, the average dimensions being: length 105 feet; breadth, 20 feet; depth. 12 feet. They are fitted with three cylinders (12 inches by 20 inches by 33 inches), with a stroke of 24 inches. The boilers develop a pressure of 200 lb. to the square inch. The dimensions of the boilers are generally 11 feet 5 inches by 11 feet, or 12 feet 6 inches by 10 feet 6 inches. The average speed of a catcher is 12 to 15 knots. This is considerably less than the pace at which a whale can travel; and the animals are therefore only hunted when feeding, since it is useless to pursue them when running. When feeding the blue whale is easy to take. The draught of a catcher is 12 feet at the stern, where the engines are placed; the draught at the bow is from 2½ to 3 feet less. This difference gives greater facility in turning; and for the same reason the vessels are fitted with a centre rudder. Motor-boats have been tried, but were found unsatisfactory, as the engines used proved to be too noisy.

2.—Improvement in Plant, etc.

In the year 1914 the industry was being carried on by most modern methods and with up-to-date plant. No improvements in material, equipment, or guns have been suggested; but, in any case, owing to the War, there has been no opportunity for making improvements. The large mean yield of oil in years of a numerically small catch of whales might in part be explained by the greater yield of certain species, which species might be present in such years in high proportion; but oil certainly escaped and was lost when whales which could not be treated immediately were reserved until attention could be given to them.

3.—Grading of Oil.

It is possible at a shore station to grade the oil according to the colour, smell, and fatty acid content; but grading on a floating factory is a matter of some difficulty.

4.—Employees.

For the conduct of the whaling industry it is essential to have very energetic people possessing long experience. Whaling is only remunerative if the working hours during the season are utilized to the full. The very best tackle and plant must be available. Up-to-date steamers are required; they should be seaworthy and of good speed, and must be easy to manœuvre. The catch manager must possess full knowledge of modern whaling, and must be capable of supervising all the men, from the harpooner to the ordinary workman. He must be able to detect and to remedy all defects and mistakes, as success depends on his capacity to do so. On the catch vessels work proceeds day and night without any fixed working hours, leaving very little time for sleep or recreation. The workmen at the factories and at the boilers on board must be strong and willing men, who can endure and be ready to take on night work when required, as this happens frequently. The regular working day is from 6.0 a.m. to 6.0 p.m. The rates of pay of the skilled employees at a shore station at South Georgia, and of the crews of whale boats operating in that Dependency, are shown in Annexures I. and II. The rates for the crews of a floating factory and whale catcher at the South Shetlands are given in

Annexure I. Wages have risen considerably during the War, and are unlikely to fall materially for some time. It will be seen that on the vessels the men are paid a monthly wage, plus a bonus for each whale, the amount of which varies with the species. On the average a gunner would earn about 15,000 kroner from the time of leaving Norway at the beginning of September until his return about June in the following year, the fixed monthly pay being reckoned from Norway to Norway. Wages are higher in the South Shetlands than at South Georgia, owing to the longer period of light during which work can be carried on. The engineers and sailors require special training. The latter must have experience in order to detect the whale from the crow's nest, and must be trained steersmen in order to act promptly and accurately on the gunner's instructions. The work is hard, as the crew must be constantly ready to attack a whale at any moment. The officers and men of the whale catchers live on board the whole time—the men are accommodated in separate bunks, while cabins are provided for the officers.

5.—Whale Meat.

Whale meat is useful for human food, but has to be used within twenty hours after the killing of the whale. It is improbable that whale meat by itself hermetically preserved would be useful for human consumption, as it is too dry and stringy; but mixed with pork fat it could be made into sausages or meat cakes. Maize for pigs, if kept on the island, could be brought from the Argentine. It is not possible to get rid of the characteristic flavour of the flesh. Since it is necessary to treat the meat while absolutely fresh, a central canning factory would not be practicable for the whole of South Georgia. A canning factory would have to be set up at each station.

6.—Whale Guts.

Whale guts have been sent from the Faroe Islands to Copenhagen for experimental purposes as to the practicability of utilization, probably for sausage skins. The experiment was, however, unsuccessful, as the guts were found to be too thick.

7.—Government Regulations.

The existing regulations give general satisfaction to the Norwegian companies.

8.—Habits of Whales.

The habits of the whales have not been studied as thoroughly as could be desired. The various kinds of whales have different habits; the humpback and the fin whale are gregarious, and are generally met with in large or small schools, whereas the blue whales are generally met singly. The humpback whale generally prefers the cold waters; but, towards the end of the period of pregnancy, it generally seeks warmer waters, although humpbacks are found in South Georgia all through the winter; these are apparently not pregnant. Generally speaking, they go north about May, returning in October or November; but the time of their reappearance varies in different seasons by as much as two months, and is no doubt determined to some extent by the distribution of the whale feed. When they return they are not in first class condition, but fatten quickly. Kril is not found north of South Georgia, and humpbacks, when seen in the neighbourhood of the line, have not been observed to be feeding. At South Georgia there is no great abundance of small fish, but the humpback is in some few cases found feeding on fish, these specimens appearing to prefer it to kril. The blue whale and the fin whale are supposed to remain constantly in cold waters. The wanderings of these whales are probably around the Antarctic Ocean, and their food is chiefly kril. In the South Shetlands the fin whales move from south-west to north-east in February and March. This migration is with the current; but at the same time blue whales are moving from north-east to south-west.

9.—Composition of Schools.

The whales do not generally congregate in schools containing animals of the same size and sex, but in schools containing all sizes and both sexes.

10.—Catch Statistics.

It would be wrong to rely on the catch statistics, and on the basis of such statistics to conclude any partial extermination of the whales, such as, for instance, the humpback whale. So many things influence the arrival and the departure of the whales, as, for instance, varying directions of the currents, which carry the food away; or the whales may find such masses of food elsewhere that they remain

absent or are delayed for months. The reason for hunting the blue whales and the fin whales instead of the humpback whales is that a blue whale may yield up to 250 barrels of oil, a fin whale go to 100 barrels, while a humpback whale yields from 20 to 60 barrels.

11.—Identity of Northern and Southern Whales.

Probably there is an identity between northern and southern whales, similar barnacles and parasites being found on both. The humpback whale has been observed to pass the equator from south to north, but it seems unlikely that the regular wanderings are from south to north, or the reverse. Migrations from south to north by the fin whales or the blue whales are not known. Judging by the whalebone there is no difference between northern and southern fin whales.

12.—Smaller Species.

Dolphins of various kinds, small and large, have been observed.

13.—Accuracy of Statistics (measurement, sex, etc.).

Whether these statistics are correct depends on the degree of conscientiousness with which they are worked out, since the measurements are difficult to make and occupy time. They are of little value unless exact, and probably only a few are sufficiently accurate for the purposes for which they are required. Measurements taken at floating factories are unreliable; but the measurements of the length of carcasses can be taken at a shore station with a considerable degree of accuracy, since flensing platforms are marked out in feet. Such measurements are probably correct within a foot.

14.—Breeding.

Whales begin to breed when about two years old, but Captain Sörlle would not hazard an opinion on the point. It is very difficult to say in what months the pairing takes place, but probably before the end of lactation, i.e., within three and four months of the birth of the young. It is not possible to judge from the size of the embryo, since at the same period a very small embryo may be found in one whale and a very large one in another. Humpbacks pair about the month of September, the birth of the young taking place in warmer waters about nine to eleven months later: smallest humpback met with at South Georgia about 20 feet long (accompanied by mother). Fin whales and blue whales apparently have no definite pairing season, and the period of pregnancy is probably somewhat longer than in the case of the humpback. The humpback is supposed to breed once a year; the fin whales and blue whales somewhat less frequently. These views are, however, merely conjectural, and their is no definite scientific evidence. It is difficult to say what proportion of the females actually breed, but embryos are found in about seventy-five per cent. of the cows taken at South Georgia. The length of the young at birth probably depends on the size of the mother whale. Calves of fin whale and blue whale occasionally are seen with their mothers at South Georgia all the year round, milk being still produced by the mother. The calves are probably weaned about three or four months after birth; cows have been taken containing an embryo and also showing signs of giving milk.

15.—Diminution of Humpbacks.

The number of humpbacks taken at the Dependencies is very small in proportion to the total number in the Antarctic seas; and the diminution in the number at South Georgia has no serious significance from the point of view of the preservation of the species. There is no reason to suppose that the stock of humpbacks is decreasing. There are, in the open seas, areas full of whales where they are not, and cannot, be hunted. Also humpbacks have been seen in large numbers off the Clerke Rocks, which are situated too far from the stations at South Georgia for practical whaling purposes. Although so many humpbacks have been killed—and the humpback is more inclined than the fin whales and blue whales to be driven away by whaling operations—any particular area which had been depleted could probably be repopulated in a period of about ten years. The pursuit of the humpback has diminished of late years with the introduction of equipment suitable for dealing with the larger whales. The fin whales and blue whales are, as already stated (section 10 above), preferred on account of the larger yield of oil; and the humpback is, in fact, often deliberately passed by in order to pursue the larger species. The killing of a cow accompanied by a calf is prohibited in the

Dependencies of the Falkland Islands. A similar prohibition is desirable as regards South America and Africa.

16.—Future Whaling.

Apart from the operations in the Dependencies, whaling is being carried on on a small scale off Alaska and the African coast. No whaling is taking place in Australian waters. Two small boats have been operating off Brazil. It is doubtful whether whaling will revive in these localities to any great extent after the War. Considerable sums have been lost; but if the price of oil should remain high some companies may start again.

17.—Marking.

For this purpose metal cases or cylinders have been fired into the whales from rifles; but none of them has been recovered. The method of firing the rifle from the shoulder is unsatisfactory—some form of rest with a swivel attachment is necessary. Harpoons recovered from carcasses have in some measure indicated the extent of the whale's migration. The whalers would willingly co-operate in recovering any marks shot into the whales; and the *Whaling Gazette* would be the best medium for developing the initiation of systematic marking experiments. Motor-boats could be used for the purpose; and it should be possible to obtain motor engines sufficiently silent for the purpose.

18.—Fur Seals.

Fur seals have been observed at South Georgia in different places. On the Annan Cove Isles up to 30 seals were observed in one school in the water; and schools of from 12 to 15 have been observed in the water in other places. Fur seals have also been observed near Clerke Rocks. On several occasions I have met Americans who reported having caught fur seals at the north-western points of South Georgia. They have also caught fur seals at the Sandwich Group. On one occasion 270 seals were caught at South Georgia, and on another over 300 at the Sandwich Group. By not hunting the seals during a period of ten years I am convinced that the result would be a considerable stock of seals, and if some specimens could be brought from other places I believe it would be advantageous. The last occasion on which my men observed 30 seals in one school was in 1911. In 1906 an American schooner caught 170 seals at South Georgia.

November, 1918.

I.—Wages on Land Station at South Georgia, 1917-18.

The manager's earnings as a rule are 30,000 to 50,000 kroner a year.

	Wages per month.		Bonus.
First foreman	250 kroner	...	15 öre per barrel oil
Second foreman	180 „	...	8 „ „ „ „
Third foreman	120 „	...	4 „ „ „ „
Engineering foreman ...	250 „	...	10 „ „ „ „
Two mechanics	150 „	...	5 „ „ „ „
One mechanic	120 „	...	4 „ „ „ „
Two blacksmiths ...	120 „	...	5 „ „ „ „
Eight cookers	100 „	...	5 „ „ „ „
One steward	350 „	...	5 „ „ „ „
One cook	150 „	...	4 „ „ „ „
One cook	120 „	...	4 „ „ „ „
One storekeeper	300 „	...	6 „ „ „ „
One cooker (open boiler)	200 „	...	6 „ „ „ „
One cooker (open boiler)	150 „	...	4 „ „ „ „
Eight cookers (pressure boilers)	100 „	...	3 „ „ „ „
Workmen	80 „	...	2-3 „ „ „ „
Two flensers	170 „	...	6 „ „ „ „

	Wages per month.		Bonus
Two flensers	130 kroner	...	5 öre per barrel oil
One carcass divider and manager of meat platform	150 „	...	5 „ „ „ „
About eight meat and blubber cutters (who should be experienced men)	90 „	...	3 „ „ „ „

Total of staff and workmen at each South Georgia station as a rule from 130 to 150 men. Those enumerated above are the specially skilled men wanted.

II.—Wages of Whaling Boat Crews at South Georgia, 1917-18.

Position.	Monthly Wages. Kroner.	Share per Blue Whale. Kroner.	Share per Fin Whale. Kroner.	Share per Humpback Whale. Kroner.	Share per Sperm Whale. Kroner.	Share per Right Whale. Kroner.
Gunner	150	80	50	30	100	200
Mate	250	9	7	5	20	20
Steward	200	7	6	5	20	20
Seamen (4) ...	150	7	6	5	10	10
First engineer ...	350	18	12	9	40	40
Second engineer ...	300	15	10	7	30	30
Firemen (2) ...	140	6	5	7	10	10

The above-mentioned wages are approximately those paid recently.

III.—Wages at the South Shetlands, according to Crew List of Floating Factory Whaling Boats, 1918-19.

Position.	Wages per Month. Kroner.	Share per Blue Whale. Kroner.	Share per Fin Whale. Kroner.	Share per Humpback Whale. Kroner.	Share per Sperm Whale. Kroner.	Share per Right Whale. Kroner.
Gunner	350	80	50	30	100	200
Mate	250	7	7	7	—	—
Cook	150	6	5	4	10	10
Seamen	140	6	5	4	10	10
First engineer ...	350	18	12	9	40	40
Second engineer ...	250	15	10	7	30	30
Firemen	140	6	5	4	10	10

Floating Factory.

	Wages per month.		Bonus.
First mate	415 kroner	...	15 öre per barrel oil
Second mate	250 „	...	10 „ „ „ „
Third mate	210 „	...	8 „ „ „ „
Boatswain	150 „	...	6 „ „ „ „
One steward	350 „	...	12 „ „ „ „
Two cooks	150 „	...	5 „ „ „ „
Seamen	100 „	...	3 „ „ „ „
Firemen	100 „	...	3 „ „ „ „
First cooker	350 „	...	12 „ „ „ „
Second cooker	140 „	...	8 „ „ „ „
Two pressure boiler cookers	120 „	...	4 „ „ „ „
Two first flensers ...	150 „	...	8 „ „ „ „
Two second flensers ...	120 „	...	6 „ „ „ „
One carcass divider ...	150 „	...	8 „ „ „ „
One first engineer ...	500 „	...	18 „ „ „ „
One second engineer ...	400 „	...	13 „ „ „ „
One third engineer ...	350 „	...	8 „ „ „ „

The total earnings of the catch manager as a rule amount to between 30,000 and 50,000 kroner a year.

APPENDIX XII.

VIEWS OF CAPTAIN C. A. LARSEN ON THE QUESTION OF A CLOSE TIME TO AVOID THE RISK OF EXTERMINATION OF CERTAIN SPECIES OF WHALES.

ALREADY in 1884 I commenced my journeys in connexion with whaling, at that time hunting bottlenose in the Arctic. As always, I observed the animal life with keen interest, and it has specially been the whales that I have watched. It may be argued that all kinds of whales can be exterminated by too intense hunting; I agree that the stock of certain species, such as the Greenland whale, can become very thin in that way, but then it must be borne in mind that a catch of a few Greenland whales is enough to cover the expense of the expedition. The outfit is nothing like so costly as that of modern companies hunting blue whales, fin whales, and the humpback whale. Their outfit is so costly that if the catch is not very large then a "close time" will come automatically. The companies will have no option but to cease working. That is shown already now; the low oil prices which England has found it necessary to fix in recent years will make it difficult to continue whaling in the Antarctic unless prices can be increased considerably. This in itself provides partly a "close season." Then the whales are protected by the fact that the points from which the catch can take place, viz., South Georgia and South Shetland, are but tiny spots in these vast waters in which they can multiply and lead their life undisturbed. There is no reason to fear extermination, especially of the large whales, as, unlike some other kinds, for instance, the humpback whales, they do not seek the coasts as breeding grounds. Even the humpback whale is protected by the fact that thousands of them seek coasts where no whaling is done. Thus a large contingent of this species is safeguarded for the future and the ocean. Should, however, the number of humpbacks diminish decisively, then attention should be given to the breeding grounds. One might prohibit the *shooting*, *catching*, or *killing* of the species it is desired to protect. It might be decided to do this for a period, or merely during the season when pairing takes place, and when the young ones are born.

I am absolutely of opinion that no danger threatens, as the humpback has his undisturbed haunts in the ocean; we have many proofs that he is a migratory animal going from ocean to ocean. Personally, I have found in these whales divers kinds of hand-harpoons, which have been sticking in the animals many years. Cartridge cases have also been found. In a right whale I found a lance which must have been there for ten or twenty years. It was bent backwards from the shoulder-blade, but the point did not get farther out than within ten inches of the outer side of the blubber. The other end had gradually rusted away till it was three inches inside the blubber. The lance had become encrusted in a bone-like substance about six inches in diameter.

It has been questioned whether the humpback crosses the equator. I can testify that I have seen both the humpback and the bottlenose cross the equator, both going south and north. I have never observed the blue whale or the fin whale crossing the equator, but I have observed the fin whale near the equator along the Brazilian coast, so I am inclined to believe that he crosses and recrosses. I have noticed that the whales go at a great speed in those warm waters, and remain submerged for a long time before coming up to breathe. I have never seen blue whales so far north. I saw many whales between South Georgia and the Sandwich group on my expedition. North of Clerke Rocks I saw masses of humpbacks, which nobody catches on account of the distance. By all the islands of the Sandwich group I saw blue, fin, humpback, and sperm whales, likewise bottlenose. I also saw "vaagevhal," or "minkehval" (piked whale, lesser rorqual), which sometimes appears in schools by South Georgia. Further, I saw grampus, the worst beast of prey among whales. It goes for the young humpbacks swimming with their mothers. I have often seen them attacked and killed in ten minutes. By the Sandwich group I have even seen the grampus kill a fin whale swimming in the whale-blood. The sea was full of pieces of blubber; the whole thing lasted half-an-hour. Besides human beings, the whales thus have other enemies, which tear them to bits.

When speaking of the Antarctic whales we must reckon with those hundreds of thousands which live along the edge of the ice and along the land. There are two oceans in those ice regions which protect the whales, viz., Weddell Sea and Ross

Sea. In the latter there are immense masses of whales, and it will probably be long before anybody takes to hunting them.

Nor should the waters of Japan and farther north, as well as the coast of Alaska, be forgotten.

I do not believe it is possible so to deplete the stock of the so-called fin whales so that posterity may be without them. As a rule they sink in rough sea, and then they are difficult to catch.

These are my views on the question of protecting them by a close season.

The whales have habits. Thus, the humpback hardly ever appears alone, but prefers company. They generally appear in small or large schools. If disturbed when feeding and the disturbance is repeated they go farther and farther away. This has often been proved at South Georgia. Fin whales, and particularly blue whales, appear singly or a few together. The fin whales may appear in large or small schools. Both these species are as a rule travelling from place to place. The chief food of the humpback is "krill," but he also eats fish. I have met with humpbacks which have lived exclusively on fish up to eighteen inches long. Apparently when he has started eating fish he prefers it, as I have found their stomachs filled to the utmost capacity with fish and no "krill," although others in the same school have been full of "krill" and no fish. The blue whale feeds on "krill" only. The fin whale eats "krill" as a rule, but sometimes has feasts on herrings. The sperm whale evidently eats anything which the vast deeps have to offer. You can find fish five or six feet long in it, but cuttlefish is its favourite diet. It swallows large specimens in great quantities.

November, 1918.

APPENDIX XIII.

MEMORANDUM ON THE DISTRIBUTION OF THE WHALES IN THE WATERS ABOUT THE ANTARCTIC CONTINENT. By JOHAN HJORT. (1914.)

1.—Knowledge of the Species of comparatively recent date.

Among the higher orders of animals, and especially among the mammals, no group has remained so little known until quite recent times as that of the whales. Up to the last, there has been doubt as to the comparatively few species, and even more as to the geographical distribution of these. It has not been an easy matter for scientists in general to obtain specimens of these animals for purposes of investigation, neither from the whalers nor by capturing them personally; few scientists have, with the exception of the Prince of Monaco, actually taken their specimens themselves. The scientific material available was thus for a long time restricted to occasional stranded specimens, and the reports of the whalers. Nevertheless, a considerable amount of information has, in course of time, been collected by such means; among other works on the subject may be mentioned the contributions of Eschricht, P. J. Van Beneden, and G. O. Sars; and by a generation ago the most important species had, roughly at least, already been described. In spite of this, however, such knowledge as had been obtained, being stored in museums or in the form of literature, was of but little use for the purpose of scientific expeditions, where the study of the subject had to be pursued by direct observation of the whales in their natural element. The task of the observer is here a matter of considerable difficulty, the object appearing perhaps only for a moment, and even then frequently showing only head, or back, or tail. Even zoologists acquainted with the species from specimens preserved in the museums, or from the best illustrations existing, may, therefore, at times find themselves unable to determine to what particular species an animal seen in the water belongs.

The whalers were for a long time similarly situated. The first object of the whaling industry was, it will be remembered, the right whale (genus *Balaena*) which is distinguished from all other species of whalebone whales by the lack of dorsal fins. These whales, of which three species are found in the Atlantic—viz.: the Greenland whale (*Balaena mysticetus*, L.) the nordkaper (*Balaena glacialis*, Bonnet, or, as it is more often called, *B. biscayensis*), and the southern right whale (*B. australis*, Desmoulins)—are remarkable for the size of their whalebone. For this reason they have been termed by the whalers "true" or "right" whalebone whales; and in the early days of the whaling industry, when whales were sought almost exclusively for

the sake of the whalebone, and the method of capture forbade any attempt to attack the far stronger and more dangerous fin whales (rorquals), it was only necessary to distinguish between right whales and rorquals. These latter were of little value to the whalers, many of whom, therefore, never learned to distinguish between the different species of rorquals, but used the name fin whale as a comprehensive term, embracing the genera* *Balaenoptera* and *Megaptera* (*Balaenoptera musculus*, L., or blue whale; *Balaenoptera physalus*, L., in Norway known as the true fin whale, or herring whale; *Balaenoptera borealis*, Less., in Norway called "seihvalen"; *Balaenoptera acutorostrata*, Lacép., in Norway called "vaagehvalen"; and *Megaptera longimana*, Rudolphi—*nodosa* and *boops*—or humpback, hunchback, knurrwal, knölhval).

When the whaling industry subsequently came to include the capture of sperm whale or cachalots, these were for a long time the principal object, right whales, however, being taken occasionally as opportunity occurred. Also this branch of the industry, the sperm whaling, left the fin whales as a rule severely alone, and the fin whale industry did not commence until the well-known invention by Svend Foyn, of explosive harpoons, with guns fired from the ship, and land factories or whaling stations on shore. Svend Foyn commenced his operations in Finmarken, in the northernmost part of Norway, in the sixties of the last century. The fin whales were, with very few exceptions, the only whales found in these waters, and the catch consisted, for by far the greater part, of the following four species: *Balaenoptera musculus*, *physalus*, *borealis*, and *Megaptera boops*.

2.—The Fin-whale Industry largely responsible for increased knowledge of Whales.

From the moment when these whales became the object of a special industry, a large amount of information was naturally collected in various ways as to the species concerned. This was the more easy as the whales taken by the new method were hauled up on land and dealt with there instead of from the ships. Both whalers and scientists had thus an excellent opportunity of making observations and noting points of importance which might serve to elucidate biological questions in regard to the whale—as, for instance, the shape of the body, contents of stomach, size of the fœtus at various times, etc. A number of new and important scientific works also appeared dealing with the system and biology of the fin whales, all based upon the material brought to land by the whalers (G. O. Sars, R. Collett, G. Guldberg, Kükenthal, etc.). The fin whales have thus been effectively systematized, at any rate as regards the region of the North Atlantic. Later investigations, and in particular the excellent work of Racovitza, have shown that the fin whales in northern and southern waters may be regarded as being in all essentials the same forms. Since the commencement of the fin-whaling industry in the Atlantic in 1905, the logs of the whalers have furnished a great amount of material as to the occurrence of the different species.

In the course of the industry it was soon found necessary to be able to distinguish between the different species, not only when the specimens were hauled up on land, but also in the water. The gunners in particular soon became practised in this respect, and were able before long to recognize the different species at considerable distances by their "spouting" alone. I have already previously called attention to the knowledge which these men possess, and to which I have myself endeavoured to attain. In my book, "Fiskeri og Hvalfangst i det nordlige Norge"† I refer to the subject as follows:—

"The humpbacked whale spouts a very short, broad (thick) jet of vapour. The spoutings of the fin whale and blue whale are most alike, that of the latter, however, being more even, and resembling a thin high jet of steam, while the fin whale's spouting is quite thin at first, widening upwards to a fountain-like cloud. The 'seihval' and 'vaagehval' are recognizable by their size alone, being smaller than the three species already mentioned."

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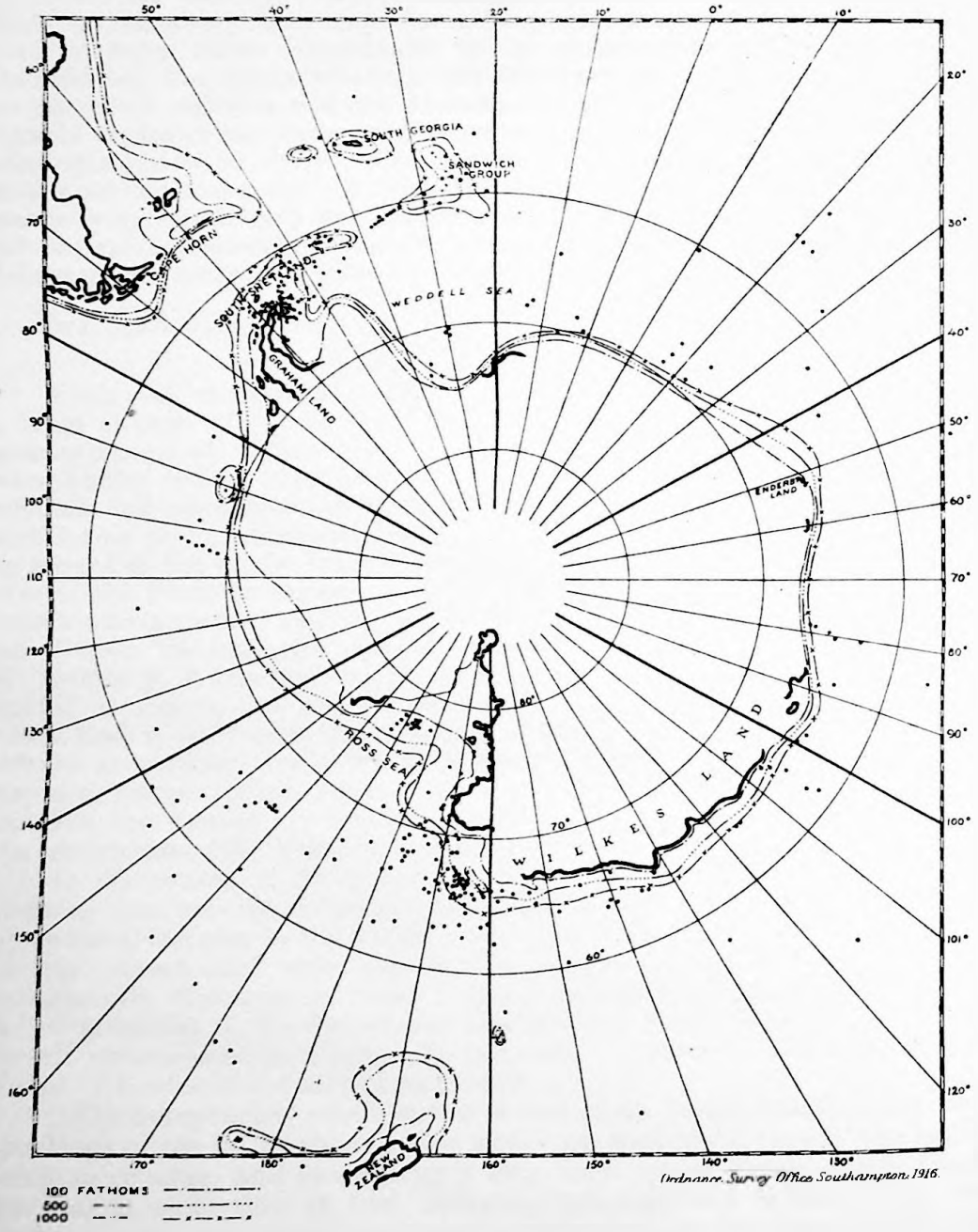
* Following Mr. Frederick W. True (on the nomenclature of the whalebone whales in the tenth edition of Linnæus' *Systema Naturae*, Proc. U.S. Nat. Mus. XXI., 1898), I feel obliged to use the name *Balaenoptera musculus*, L., instead of *B. Sibbaldi*, for the blue whale, and the name *Balaenoptera physalus*, L., instead of *B. musculus*, for the fin whale. The latest authors, e.g., E. Racovitza and R. Collett, have also followed Mr. True in this respect.

† Johan Hjort: Fiskeri og Hvalfangst i det nordlige Norge. Aarsberetn. vek. Norges Fiskerier, Bergen, 1902.

SOUTH POLAR CHART

Fig. 1.



It was thus not until the commencement of the Norwegian fin-whaling industry that accurate knowledge was obtained as to the appearance of these species when in the water; it is, therefore, not to be wondered at that the mass of earlier literature, extensive as it is, yet furnishes but general and far from precise information as to the occurrence of the different species in the sea. Numerous expeditions, both of scientific and practical nature, have contributed material based upon observations of whales; these are, however, unfortunately, for the most part but vague, merely stating that "whales," "whalebone whales," or "rorquals" have been seen. More detailed references as to blue whale, humpbacked whale, etc., are rare in works on the subject. It is frequently possible, however, for a reader who has himself had some opportunity of observing whales to discover what species were seen in the instances recorded by the author.

3.—Earliest Methodical Investigations as to the Antarctic Whales.

The first methodical studies of whales in the Antarctic Ocean were carried out by the able zoologist, Emile G. Racovitza.* During the cruise of the *Belgica* he had ample opportunities of becoming acquainted with the different species of the genera *Balaenoptera* and *Megaptera*, both as regards their appearance and manner of life. On the basis of the knowledge thus obtained he commenced a critical examination of all the information distributed throughout the reports of the various expeditions with regard to the occurrence of whales south of the 50th degree of latitude. This work of Racovitza is extremely valuable, not only as saving subsequent investigators a great deal of trouble in searching out data from the many earlier records, but also on account of the numerous excellent critical observations as to the value of the data already given. Racovitza has, with few exceptions, studied all the original reports from Cook's famous voyages (1772-1775) to the commencement of the present century; his book was published in 1903. He is thus able to refer to almost the whole of the existing material on the subject. Of later expeditions, the most important in this respect are the German Gauss expedition, the British expeditions to the South Pole (Ross Sea), and the Norwegian South Polar expedition.

We have thus a mass of material collected throughout a period of about a century and a half (from 1772 to the present day). Racovitza, nevertheless, deals with the whole under one head, a method of proceeding which is undoubtedly justifiable, his object being to obtain information as to the distribution of the different species. It is scarcely conceivable that so great natural changes should have taken place in the waters about the Antarctic continent during the period in question as to affect the distribution of the species here. And as regards the whaling industry, this has, it is true, in earlier times taken toll of the right-whale stock in the southern hemisphere, and since 1905 of the fin-whale stock in a very restricted area of the same (the waters about South Georgia and South Shetland); this can, however, hardly have had any other effect than that of reducing the numbers.

The question as to the influence of the industry upon the stock is, therefore, a point apart, and must be considered chiefly upon the basis of experience furnished by the *most recent* expeditions. We will, therefore, first of all proceed to consider the question of the *areas of distribution of the species.*

Racovitza has found, in earlier works, nearly three hundred places recorded where whales had been observed south of the 50th degree. All these spots will be found marked on the accompanying chart (Fig. 1). He complains emphatically that these statements are only partly accurate, and frequently incorrect, as regards the distinction of species; the writers, both scientists and whalers, often merely noting points of similarity, instead of definitely stating the species. Bearing in mind what has been said in the foregoing as to the development of our knowledge on the subject, this will not be found surprising. Only few have had any previous opportunity of observing and distinguishing whales when in the water, while the whalers would be for the most part men engaged in the right-whale or sperm-whale industry, and not familiar with the rorquals. Several of the most prominent explorers, such as Weddell and Biscoe, make definite and particular statements as to occurrence of humpbacked whales, etc., whereas others, like Cook, merely refer

* Emile G. Racovitza: Cétacés. Résultats du voyage du S. Y. Belgica en 1897-99, Anvers, 1903.

to "whales," and some, as, for instance, Ross, have doubtless been mistaken in speaking of the occurrence of "right whales," the specimens seen having doubtless been blue whales.

Racovitza was, therefore, obliged to employ most carefully all available data in determining what species had actually been seen in the instances recorded. On the basis of his own accurate observation in the waters about South Shetland, he ventures to conclude—and is doubtless justified in so doing—that in nearly all cases where "whales" are reported to have been seen here, these must have belonged to one or the other of two species, viz., blue whale (*Balaenoptera musculus*) and humpbacked whale (*Megaptera longimana*), with perhaps, though more rarely, *Balaenoptera physalus* and *borealis*. The two first-named are the most frequently occurring Antarctic species, being found there together, at any rate, at that time of year when most of the expeditions would be in those waters, i.e., November-April. These two compose the true stock of *large whales* in Antarctic waters.

The "right whales" recorded by Ross must, according to Racovitza, in reality have been these fin whales, partly because no such Polar whale as the northern Greenland whale has ever been observed in the Antarctic Ocean, but only a species closely related to the Biscay whale, which has never been found in strictly Polar waters. Moreover, later writers (Bull, Kristensen), dealing with the Ross Sea, have found no right whales there, but only *Balaenoptera physalus*, *musculus*, and *Megaptera longimana*. This applies also to almost all the waters south of the 60th degree of latitude. Proceeding to a closer study of Racovitza's table of occurrences (localities where whales have been observed) we find that, of two hundred and eighty-one occurrences recorded, two hundred and forty-nine should, in his opinion (doubtless based on highly critical methods), be referred to fin whales in the widest sense of the term, i.e., rorquals (Balaenopteridæ, embracing the genera *Balaenoptera* and *Megaptera*).

4.—Occurrence of Whales in Different Parts of the Antarctic Ocean.

These occurrences group themselves very unequally about the different parts of the Antarctic Ocean. If we divide the region into six areas of equal magnitude, each embracing 60° of longitude, we find, according to Racovitza's table, the following figures :—

	Occurrences recorded.
1. From 20°-80° W.* (Coats Land, South Georgia, South Shetland, Graham's Land)	84
2. From 80°-140° W. (Graham's Land westward to Ross Sea)	6
3. From 140° W.-160° E. (Ross Sea and both sides of the entrance to same)	109
4. From 160°-100° E. (Balleny Islands towards Emperor William II. Land)	23
5. From 100°-40° E. (Emperor William II. Land to Enderby's Land)	9
6. From 40° E.-20° W. (Enderby's Land to Coats Land)	18

It will be noticed that whales have been noted in great numbers chiefly in two particular areas, viz., South Georgia, South Shetland, and the Ross Sea, with adjacent waters.

In many cases it is possible to determine not only that the whales seen were rorquals, but also to what species of these they belonged. Thus Racovitza is of opinion—and his theory seems to be fairly well borne out by the original documents—that in sixty-five cases the whales seen may with perfect certainty be classed as humpbacks, while ninety-three were blue whales. These more precise statements, moreover, show the same grouping of the whales as the general records given above. Of the sixty-five occurrences of humpbacks (*Megaptera longimana*) recorded :

Thirty-seven were observed between 20° and 80° W. (South Georgia, South Shetland);

Twenty-three between 135° and 182° E., with maximum between 160° and 180° E. (Ross Sea).

* The boundaries between these areas will be found specially marked on the chart (Fig. 1).

Of the ninety-three occurrences of *Balaenoptera musculus* (blue whale) recorded :
Thirty-five were observed between 20° and 80° W.; and
Forty-three were observed between 135° and 180° E.

Racovitza at once points out, however, in this connexion, that these facts are not sufficient in themselves to warrant the immediate conclusion that the stock of whales is only numerous in these two localities—the present field of operations, and the Ross Sea. Various other circumstances have here to be taken into consideration.

In the first place, there is, of course, the fact that the number of expeditions varies greatly for the different parts of the Antarctic, at any rate as regards the higher degrees of latitude. The object of most of these expeditions has been either to discover new land, or to reach a particularly high degree of latitude—if possible, the Pole itself. For both purposes, the two areas mentioned, between 20° and 80° W. and 160°–180° E., have been regarded as especially favourable, and expeditions have, therefore, been particularly numerous between these degrees of longitude. True, there have been many instances of circumnavigation, i.e., round the whole of the Antarctic Ocean; these expeditions have, however, for the most part sought to avoid the ice, keeping to the north of those latitudes where the whales are to be found during the Antarctic summer. According to Racovitza's table the blue whales have been found to be distributed (during the Antarctic summer) between 61° and 71° S., with a maximal occurrence about 63°, 64°, or 66° S. The humpback is found between 60° and 67° S., with a maximum of occurrence between 63° and 64° S. The areas above referred to are almost the only places in these latitudes visited by expeditions, or rather the only places where any expeditions have made a stay of any considerable duration. On account of the great masses of icebergs and pack ice, which are the occasion of so much difficulty and danger to explorers in these regions, it is rarely that any of them have ventured far to the south outside these two areas—the Ross Sea, and the vicinity of Graham's Land. Some exceptions there are, however, and these of particular interest, the expeditions in question being those of the ablest and most reliable of all Antarctic explorers. I will here cite a few of these expeditions with the observation made.

Along the range westward from Graham's Land to about the mouth of Ross Sea (80°–140° W.) some of the most reliable investigators have recorded the sighting of whales in high latitudes, as, for instance, Biscoe, Bellingshausen, Enderby, and Wilkes. Biscoe states (at 81° 50′ W.–66° 27′ S.) "several hump and finbacked whales"; Bellingshausen (at 114° 18′ W.–63° 26′ S.), "whales round about."

West of the Ross Sea, between this and the longitude of South Georgia, whales have been seen by a number of expeditions; Biscoe, Enderby, McNab, D'Urville, Wilkes, the *Challenger*, Bellingshausen, and, in recent times, the German Gauss expedition. We find, for instance, the following statements :—

15° 51′ E.–69° 06′ S. A great number of whales (Bellingshausen).
23° E.–68° 50′ S. Some fin and humpbacked whales (Biscoe).
35° 03′ E.–67° 15′ S. Many whales (Cook).
41° 26′ E.–66° 49′ S. Many whales (Bellingshausen).
78° 22′ E.–66° 40′ S. Numerous whales and grampus (*Challenger*).
About 80° E. to about 65° S. A few whales (*Challenger*).
80° E.–62° 30′ S. Whales seen (*Challenger*).
87° E.–63° 45′ S. Some whales (*Challenger*).
97° 37′ E.–64° 01′ S. A large number of finbacks (Wilkes).
103° 49′ E.–61° 15′ S. Great number of whales (McNab).
104° E.–64° 06′ S. A vast number of whales (Wilkes).
106° 10′ E.–65° 28′ S. Many whales (Wilkes).
116° 11′ E.–63° 56′ S. Great many whales (Enderby).
134° 50′ E.–63° 40′ S. Great many whales and porpoises (Enderby).

We thus find that, even in those parts of the Antarctic where observations are few, many whales have yet in course of time been observed. It will be noticed that all the localities here recorded are in *very high latitudes*, i.e., *near, in, or far up among the pack ice*. This is explained by Racovitza, and by whalers acquainted with the habits of the animals, as due to the fact that the most important, i.e., most numerous and valuable species, the blue whale and the humpback, seek either the ice or the land. The blue whale is perhaps most frequent among the ice, the humpback having possibly some preference for land. As regards this point, considerable experience has been obtained in the course of the whaling industry in *northern* waters. As I have previously pointed out, on the basis of information from Norwegian whalers, these were either taken near the coast of Norway, Finmarken

(especially the humpbacks, when these had moved over to the westward) or northward in the vicinity of the ice. If it be permissible to draw conclusions from these facts with regard to conditions in the Antarctic, then this would explain why vessels sailing round the globe, as, for instance, the *Terra Nova* and *Fram*, and passing from the Atlantic to Ross Sea, would encounter but few whales in the sea far north of the ice in lower latitudes. Not until they had penetrated far to the southward, and approached or reached the pack ice, were whales found in numbers. Racovitza, judging from his experience in the course of the *Belgica* expedition, is able to assert that the two most important species, the blue whale and the humpback, both have a preference for localities in the neighbourhood of land, the former, however, in a lesser degree than the latter. He states as follows :—" These fin whales (the blue whales) are frequently found to accompany the humpbacks; their area of distribution is the same. Widely distributed as they are around the whole extent of the Antarctic pack ice, they are still, however, far more numerous near land than in the open pack ice."

5.—Numerical Value of the Whales.

The question as to the *numerical value of the whales* is naturally a point of considerable difficulty. An observer on board a ship at sea is unable to see very far to either side. Nor can the distribution of the whales be supposed to be so regular that the comparatively few cruises which have been made in the Antarctic Ocean should suffice to give any *quantitative* idea. Little has been done, moreover, in the way of making any accurate record of the whales seen, or noting the definite number of same observed. " Many whales," " few whales," " some whales," are after all but vague expressions. One thing, however, is certain : reports from all parts of the Antarctic mention the occurrence of great numbers of whales, both in former and in more recent times.

6.—South Georgia—Graham's Land.

No expedition has attempted to give such accurate information concerning the number of whales seen as that of the *Belgica*. An endeavour was here made actually to count the whales seen in the course of a day, and Racovitza states that in the Belgica Straits (off Graham's Land) over 100 humpbacks and 50 blue whales were sighted in one day. That the whales continue to be found in great numbers in these waters up to the present day, the fact that the whole of the whaling industry is concentrated about this area, is borne out by the great catches made as late as last season both in the South Georgia and South Shetland waters. The three whaling vessels belonging to the Tönsberg Company, working in South Georgia, took in the course of the season 1912-13, no less than 313, 294, and 286 whales respectively.

The great catches made of late years in the waters between South Georgia and South Shetland render it superfluous to dwell further on these localities in this connexion.

7.—Ross Sea.

Turning then to the second great area of the Antarctic, where whales have been recorded from many localities, viz., the Ross Sea and adjacent waters, between 140° W. and 160° E., we find very numerous proofs that all explorers, from the earliest until most recent times, have had a distinct impression of these waters as being the haunt of a great stock of whales. In order to justify this assertion it will be necessary to quote the exact statements of various writers. I will commence with some of the earliest.

When Ross, in December, 1840, started southward from Tasmania on his first voyage towards the pack ice, he sighted, on the 29th December, latitude 63° 25′ S., longitude 174° 31′ E., amongst numerous icebergs and much drift ice, a great many whales, chiefly of the common black kind, greatly resembling, but said to be distinct from, the Greenland whale. They appeared to be of unusually large size.

On the 1st March, 1841, at 69° 04′ S., 167° 37′ E. (in Ross Sea), Ross writes: " We saw a great many whales whenever we came near the pack edge, chiefly of a very large size, and I have no doubt that before long this place will be the frequent resort of our whaling ships," etc.

McCormick, who accompanied Ross, says of the Antarctic Continent, and of Ross Sea in particular: "In open water whales were spouting in all directions, chiefly the finner, and a beautiful grampus, or small whale." In Racovitza's list of localities where whales have been seen, he notes, between 140° W. and 16° E., in Ross Sea and among the pack ice outside, no less than twenty-three different spots where Ross or his companions, McCormick and Craig, have recorded the occurrence of "many whales," "great many whales," "numerous whales," etc. The places where "some whales," "several whales," etc., were seen are not included here. Although Ross, who had no independent knowledge of the different species, is here at fault, having mistaken the rorquals (chiefly, no doubt, the blue whales) for right whales, the extracts from the logs of the expedition suffice to prove distinctly that *blue whales and humpbacks were encountered in very great numbers.*

I may mention that, in the course of an earlier expedition, ably conducted on board the schooner *Eliza Scott*, McNab's log-book records the occurrence of numerous whales in the same waters. Thus, about 180° and 66-70° S., where we find "many whales," "whales in all directions," etc.

The erroneous statement made by Ross as to the occurrence of right whales in Ross Sea led to the starting of an expedition by Kommandör Svend Foyn, at the instigation of Mr. J. Bull, a steamer, the *Antarctic*, being equipped for the purpose of ascertaining whether a right whale industry could be established in those waters. The expedition penetrated into the Ross Sea, and soon discovered that no right whales were to be found. Blue whales and humpbacked, however, were encountered in great numbers. Mr. Bull states that during the voyage down to the mouth of Ross Sea, they saw, on the 5th December, 1893, at 65° 47′ S., 171° 36′ E., several blue whales and humpbacks. On the 12th December some blue whales were seen, of which two were harpooned.

On the 22nd December, twenty five miles from the Balleny Islands, at the entrance to Ross Sea, another blue whale was harpooned.

On the 12th January, at 68° 7′ S. (in the Ross Sea), "blue whales in all directions" were seen. On the following day we find a remark concerning the blue whales: "We sight a quantity of these animals, both by day and night; as many as twenty may frequently be counted in quite a short space of time. With a whale-boat and a big transport vessel it should be possible to make good catches in the big open canals. The red 'shrimps,' which form the whales' daily food, are found here in the same quantities as in northern waters."

"7th February. Steering towards Balleny, which we could just see. Many whales around, all, however, of the finned family."

Since the commencement of the fin whaling industry in the Antarctic (1905), a number of important expeditions have been sent out to Ross Sea. Of these it will, in this connexion, suffice to mention those of Shackleton, Scott, and Amundsen.

In Shackleton's book ("The Heart of the Antarctic," London, 1909) James Murray, the biologist of the expedition, writes of the occurrence of whales in the Ross Sea, as noted by the expedition (which covered the period from 1907-1909). Murray writes of the stay at the Great Barrier, and the bay in which the ship remained so long:—

> "This bay, which we afterwards referred to by the appropriate name of the Bay of Whales, was teeming with all the familiar kinds of Antarctic life. Hundreds of whales—killers, finners, and humpbacks—were rising and blowing all round." (Volume II., page 234.)

As regards the whales in general, he writes (Volume II., page 260, ff.):—

> "In summer whales were locally abundant, though nowhere else in such numbers as we saw in the Bay of Whales at the Great Barrier. As long as there was open water small schools of finners and larger ones of killers were seen daily in McMurdo Sound. Even when the Sound was densely filled with pack they came to the little sea-pools. For a long time in winter no whales were reported.
>
> "The finner, with its little fin about half-way along the back, and its long, pointed head, came very near, and often grazed the ship. One came vertically up close by the ship's side, the snout ten or twelve feet out of the water. As usual, in such emergencies, none of the cameras was ready.
>
> "The killers were often in family parties, or a few families together, some bulls of great size, with magnificent triangular fin, like a boat's sail, six or eight feet long, the cows with much smaller, often curved, fin, the

calves following close by their mothers' tails to avoid getting lost. Some very small calves were seen in January.

"The humpback, with little rounded fin set far back, and the bottle-nose, were rarely seen."

Scott's expedition from 1910-12 ("Scott's Last Expedition," London, 1913) also gives a very distinct impression of the great numbers in which the whales occurred. During the voyage southward towards the pack ice, Scott himself writes in his journal as follows :—

"8th December, 1910 (63° 20′ S., 177° 22′ E.). We have seen a good many whales to-day, rorquals with black snouts—*Balaenoptera sibbaldi.*"

At 67° 35′ S., 160° 16′ E. "A number of whales (lesser rorquals) were in this pack, and they soon discovered this clear water and took advantage of it to come and blow. As there was not room for them to come up in the ordinary way they had to thrust their heads up vertically and blow in a sort of standing-on-their-tails position. Several times one rested its head on a floe, not twenty feet from the ship . . . ." etc.

D. G. Lillie writes: "It is true that only about three species of whale-bone whales were recognized south of the pack, but the number of individuals seen daily round the ship was very great. The two commonest species seen were *Balaenoptera sibbaldi*, the blue whale, and *Balaenoptera rostrata*, the pike whale."

Amundsen's expedition, on board the *Fram*, which visited Ross Sea several times during the years 1910 and 1911, also encountered numerous whales there. Lieutenant Prestrud writes (in Amundsen's book, "Sydpolen") :—

"The name 'Bay of Whales' was given by Shackleton, and is well chosen. From the time when the sea ice breaks up, this big gap in the Barrier is a favourite haunt of whales, which were very often seen playing about for hours at a time in flocks of some fifty strong."

Less numerous was the occurrence out in the Ross Sea itself (open water). "The most common species was the fin whale, the blue whale (?) coming next." I have inquired of Mr. Amundsen as to which species of whales he encountered in great numbers in the Ross Sea, and he has informed me that he saw blue whales, fin whales, and humpbacks in great numbers.

It would thus seem, from the extracts here given, that Ross Sea, and the pack ice outside its mouth, is now, as in the days of Ross, frequented by great numbers of the different species of rorquals, which are now the object of the whaling industry in the waters between South Georgia and Graham's Land.

8.—The Open Coasts of the Antarctic Continent.

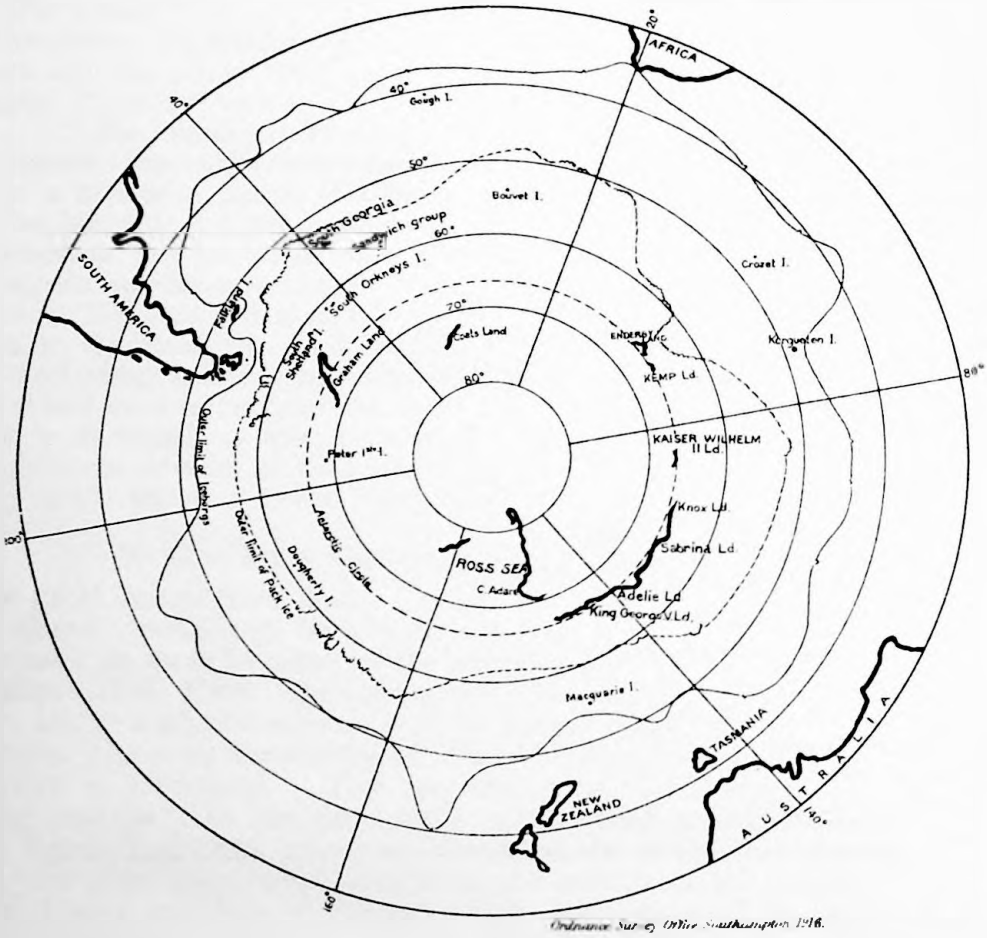
The great range from South Georgia to Ross Sea (from 30° W. to 140° E.) has, as already mentioned, been much less visited by expeditions; here also, however, mention is made by some of the ablest explorers of the occurrence of whales in numbers; thus Cook, Bellingshausen, Biscoe, Weddell, Nares (*Challenger*), Wilkes. Many such statements will be found quoted in Racovitza's work. In recent times I have no knowledge of others beyond the Gauss expedition (1902-03) under Erich v. Drygalski. This expedition is, however, in many respects of particular interest. In the first place it numbered among its members the able biologist Ernst Vanhöffen, who took charge of the methodical observations dealing with all biological phenomena, including the occurrence of whales. In the second place the winter quarters of the expedition were situated at one of the points where the Antarctic Continent juts out into the Polar Sea along this long range, where there are no bays as in Ross Sea and between South Shetland and Graham's Land. The station chosen was on the long open coast of the Antarctic Continent, and therefore in many respects representative of the same. In the course of the cruise down from Kerguelen to this land station, Vanhöffen states* :—

"From the 5th of February onwards (about 55° S., 80° E.) we had icebergs ahead every day, and nearly every day we could hear whales blowing. Of these, we could distinguish, from the position and shape of the dorsal fin, a whalebone whale and a toothed whale as *Megaptera* and *Globicephalus.*"

"On the night of the 13th-14th February, the big net, 7 m. diameter, was dragged for some hours. When it was drawn up, badly torn, it had taken some 20 litres of beautiful Euphausidæ (*E. superba*, *E. Murrayi*, and some of the small *E. Antarctica*), etc."

* Deutsche Südpolar Expedition, Heft 5, 1903. Veröff. des Inst. für Meereskunde, etc.

SOUTH POLAR CHART
Fig. 2.



At the land station (66° 2′ S., 89° 48′ E.) the whales comprised two to three species (Megaptera, Orca, and Globicephalus forms). On account of the ice the whales could not remain after the 2nd of March near the station, and were not seen again until the spring of 1903, 40 kilometres west of the station, on a sledge trip. On the 8th of February, 1903, the ship emerged suddenly from the ice, in which cracks appeared. As the ship then steamed, or slowly drifted, out towards deeper water, whales were seen almost daily from the middle of February to the middle of March, as soon as the openings between the floes were large enough to permit of whales rising close to the ship. Whales are also found in among the pack ice, also off the open coasts of the Antarctic Continent.

In this area (between South Georgia and Ross Sea) lies also, it will be remembered, the Kerguelen Island group (at 70° E., i.e., about the same longitude as the German land station, but in a lower latitude, about 50° S.). The occurrence of whales in these waters is proved first and foremost by the catches which have been made, although the islands lie much farther to the north than the general haunts of the whales. The blue whale, especially, is but rarely seen so far north, and in lesser numbers. According to one of the whaling logs before me a single whaleboat took, in 1909, 110 humpbacks, 5 finners, 2 blue whales, and 1 right whale. This also shows that whales are numerous in longitudes between the two rich whaling areas of South Georgia and Ross Sea.

9.—Seasonal Variation in the Distribution of the Whales.

When speaking, as in the present instance, and in the works on the subject referred to, of the occurrence of whales at a certain place (latitude and longitude), it must be remembered that all the statements quoted only apply to a certain *season*. In the great majority of cases the records refer only to the *Antarctic summer*, i.e., the period from November to March or April. During the winter season, from May to October, the ice moves forward, reaching as far as, or even beyond, the 50th degree of latitude (*vide* chart, figure 2). The whales must then shift their ground, partly because they cannot then find open water in which to rise to the surface, and partly because the Antarctic animal life dies out in those latitudes where it is so richly abundant in summer. Many statements are also on record from expeditions which have wintered in these regions, to the effect that the whales disappeared in the winter (e.g., the *Belgica* and Gauss expeditions, *vide supra*). Most instructive of all in this respect, however, are the entries in the whalers' logs. By the courtesy of Norwegian whalers I have been enabled to study a number of these logs, from different parts of the globe where whaling is carried on, including the Antarctic. Up to the present I have only been able to deal with a part of this material. I will, however, quote a number of examples showing the catches of the various species in different months of the year, which alone will suffice to give an idea of the movements of the whales to and from the frozen regions of the true Antarctic. I have selected for the purpose some extracts from logs referring to different Antarctic waters:—

South Shetland, Season 1912-13.

—	Humpbacks.	Fin Whales.	Blue Whales.	Total.
November	3	—	4	7
December	17	4	21	42
January	11	11	17	39
February	1	9	17	27
Total	32	24	59	115

The season here embraces, as will be seen, only the four best months, November-February, and is at its best in December-January. The catch consisted of humpbacks, finners, and blue whales.

South Georgia, Season 1912-13.

—	Humpbacks.	Fin Whales.	Blue Whales.	Sperm Whales.	Right Whales.	Total.
July	—	2	1	—	—	3
August	—	—	—	—	—	—
September	2	6	2	—	—	10
October	2	11	3	3	—	19
November	23	6	4	—	—	33
December	47	12	3	—	—	62
January	38	14	2	—	—	54
February	7	23	—	—	1	31
March	1	44	3	—	—	48
April	4	18	1	—	1	24
May	—	3	—	—	—	3
June	—	4	3	—	—	7
Total	124	143	22	3	2	294

At South Georgia the season is much longer, some whales even being found the whole year round. Here also, however, the main portion of the catch falls in the Antarctic summer months, most being taken in December-January. Besides the three species, humpback, fin whale, and blue whale, an occasional sperm whale or right whale may also be taken, which proves that these grounds lie on the boundary line of the true Antarctic Ocean. Of the different whales represented, the humpback exhibits the most distinct seasonal occurrence, being taken in numbers only during the months from November to January, as at South Shetland. The fin whale and the blue whale are apparently to be found, *at any rate single*, all the year round.

At Kerguelen and Falkland Islands the prevailing conditions are very similar to those of South Georgia, whales being taken as late as April, May, and June. Closer consideration of this area must, however, be postponed to a later date, when all the available logs have been gone through.

10.—Occurrence of Whales outside (north of) the Antarctic Ocean.

The question now arises as to whither the whales of the Antarctic move during the winter of the southern hemisphere. As to this, considerable information may doubtless be obtained from the logs of whalers working other waters outside these regions. We should thus be able to learn where the different species—or at any rate some of them—have their winter haunts. It will at least be interesting here to consider a few examples of the catches made in the warmer waters of more northerly latitudes, and I have selected for this purpose two logs from the west coast of Africa, one from Saldanha Bay, 1912, the other from Port Alexander, 1911. Saldanha Bay lies on the west coast of the southernmost part of Africa, south of 30° S., Port Alexander being situated much farther north, nearer the equator.

Saldanha Bay, 1912.

—	Humpback.	Fin Whale.	Blue Whale.	Seihval. *	Total.
March	—	5	—	3	8
April	—	—	—	23	23
May	4	6	1	11	22
June	6	2	1	6	15
July	10	3	1	7	21
August	5	2	—	8	15
September	3	—	—	—	3
October	15	—	2	—	17
November	4	—	—	3	7
Total	47	18	5	61	131

* Some, or all, of these whales may perhaps belong to the species *Balaenoptera brydei*, described by Orjan Olsen (Proceedings of the Zoological Society of London, 1913).

No whaling is carried on here in the summer months from November-March; not until May do the humpbacks appear. This species has two periods of maximal occurrence; one in June-July and another in October. This the whalers explain by the theory that the humpbacks move northward in June and south again in October; i.e., a migration towards the warmest part of the sea. The other whales are especially found during the winter months of the southern hemisphere, May-August.

Proceeding now to consider the catches of whales near the equator, at Port Alexander, we find the following figures :—

—	Humpbacks.	Fin Whales.	Seihval.	Total.
June	48	—	—	48
July	73	—	—	73
August	47	—	1	48
September	58	1	1	60
October	82	1	—	83
November	10	—	—	10
Total	318	2	2	322

The season here, it will be noticed, is still later, falling almost entirely between June and October. The catch consists almost exclusively of humpbacks. Here also we find the maxima in July and October.

11.—Migration of the Whales.

If we now compare these log extracts, it would seem to be fairly evident that the whales of the Antarctic move north during the southern winter, even penetrating far up towards the equator. This is at any rate clear enough as regards the humpback.* The periods of its occurrence in the Antarctic Ocean and the warmer southern seas alternate with perfect regularity.

The other species of whales are far less numerously represented in the catches made on the coasts of Africa. This is doubtless largely due to the fact that the blue whales and fin whales do not frequent the coasts to the same extent as the humpbacks, keeping more to the open sea, and probably do not move so far up into the warmer waters. This agrees with the observation hitherto made in Arctic regions, where the humpback and blue whale are only found from June to autumn, moving in winter towards warmer parts of the sea.†

A point of the greatest importance in considering the problem as to the size of the whale stock, and the influence of the whaling industry thereupon, is the question of how far the whales, in the course of their migrations from the Antarctic to warmer waters, keep to the same degrees of longitude all the way, or possibly follow the direction of the ocean currents. Do those whales, for instance, which are to be found during the Antarctic summer in the South Georgia-South Shetland area move in winter towards South America or South Africa? With regard to this, the material which I have hitherto been able to study furnishes no information. The only possible indication would be the finding of harpoons in previously wounded whales, in which case the whaling industry would itself provide a solution of the problem. The only satisfactory manner of dealing with the question would be by means of making experiments; the shooting of small darts into the bodies of living whales, which would be recovered when the animals were subsequently captured by the whalers. If it is desired to arrive at an understanding of such questions as the size of the stock and the percentage of same taken by the whaling industry—the "catch percentage"—then experiments of this nature would have to be made. Without them we can only have recourse to mere conjecture.

*This theory is supported by the Norwegian zoologist, Örjan Olsen, who has studied the whales at the Norwegian factories on the coast of Africa and has published a preliminary report on the same, which cannot, however, here be further considered at present (*Naturen*. 3die Hefte. 1912, Bergen).

† Fiskeri og Hvalfangst. loc. cit.

This important point is now under the consideration of the Norwegian Whalers' Society, and experiments are being made with various kinds of guns and small cannons firing darts suitable for the purpose. Only by such experiments, and by careful study of the industry itself and actual catches, will it be possible to obtain a solid and reliable basis for comprehension of the present and future position of the whaling industry.

APPENDIX XIV.

MEMORANDUM RELATIVE TO SEALING IN THE DEPENDENCIES OF THE FALKLAND ISLANDS.

1.—Species.

The southern seals are divisible, for commercial purposes, into two categories, namely, fur-seals and hair-seals. The former, as the name implies, are hunted because of the value of the skins; the latter are pursued entirely for the oil which they yield, and their skins are not utilized.

The following is a list giving the common names, with their scientific equivalents, of the various species of southern seals. The list was revised in March, 1917, by Dr. S. F. Harmer, F.R.S., of the British Museum, who pointed out that there was a want of permanence in zoological nomenclature, and that, owing to the adherence to certain rules of nomenclature, reasons are brought forward from time to time for giving up well-established and familiar names, and reverting to some name of earlier date.

1. Sea elephant (*Macrorhinus leoninus*, *Mirounga leonina*,* *Cystophora proboscidea*†);
2. Southern fur-seal (*Otaria australis*, *Arctocephalus australis*,* *Otaria ursina*†);
3. Sea lion (*Otaria jubata*, *Otaria byronia**);
4. Weddell's seal (*Leptonychotes weddelli*);
5. Ross seal (*Ommatophoca rossi* or *rossii*);
6. Sea leopard (*Stenorhynchus leptonyx*, *Hydrurga leptonyx**);
7. Crab-eating seal (*Lobodon carcinophagus*).

2.—Regulation of the Sealing Industry.

Ordinance No. 4 of 1881 provided that the period between the first day of October and the first day of April following, both inclusive, should be a close time in the seal fishery of the Falkland Islands and the then Dependencies and the seas adjacent thereto. The Ordinance prohibited the killing or capturing or the attempting to kill or capture any seal during the close season.

The expression "seal" was defined to mean the "fur-seal," "the sea-otter," the "hair-seal," the "sea-elephant," and the "sea-dog," and included any animal of the seal kind which might be found within the limits of the Colonies and the Dependencies.

Ordinance No. 4 of 1881 was repealed by Ordinance No. 1 of 1899, which provided, subject to the saving of existing rights, for the issue of sealing licences, the licensee being required to render an accurate account of the number of seal taken by him during each sealing season, i.e., the period from the 1st of April to the 30th of September, both inclusive, the remainder of the year constituting the close season. Sealing without a licence was prohibited. The Ordinance also empowered the Governor in Council:

(i) to issue proclamations prohibiting the taking in any year of one or more kinds of seal, or of males, or females, or young of any kind;

(ii) to vary in any year the limits of the sealing season for any kind of seal, or for the male, or female, or young of any kind; and

(iii) to declare any territorial waters, or any Crown land, or, with the consent of the owner, any private land, to be a seal reserve, which was defined as meaning any portion of land or water set apart for the breeding of seals.

The Governor in Council was further authorised to make rules regulating the issue of licences or the number of seals to be taken under any licence.

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* Modern name. † Norwegian name.

The definition of the expression "seal" in the Ordinance included by name the "sea-bear" and the "sea-lion," as well as the varieties specified in the definition in the 1881 Ordinance (*vide supra*). Under section 3 of Ordinance No. 9 of 1908 the Governor in Council could have extended the Ordinance of 1899 to the Dependencies, but the differing circumstances of the Falkland Islands and the Dependencies rendered a special enactment desirable; and a special Ordinance (No. 6 of 1909) was accordingly passed. This Ordinance made it unlawful to take seal in the Dependencies without a licence, and provided for the issue of licences and also for the declaration of seal reserves. On the 29th June, 1914, a regulation was made fixing the sealing season in the Dependencies as from the 1st of January to the 31st August, i.e., the month of September was added to the close season. In view, however, of the necessity for increasing the output of all kinds of oil during the War, the month of September was included in the sealing season at South Georgia in each of the years 1916, 1917, and 1918.

The whaling leases originally granted in South Georgia preclude the lessees from killing seals. The later leases prohibited the taking of sea-elephants.

The sealing licence granted in 1910 was subject to the following conditions :—

(*a*) To render an accurate account of the number and kind of seals taken, and to report and locate on the chart where such seals were found in large numbers or rookeries, or where others were observed.

(*b*) No pup or young seals to be killed or taken.

(*c*) To avoid as far as possible the killing or capturing of the female seals.

(*d*) A close season from the 1st October to the 31st December.

In later licences the take was limited to a specified number of hair-seal and fur-seal (if any of the latter): but, subsequently, instructions were given that permission to take fur-seal should not be included in the licences.

In a report made at the end of the season 1910 it was stated that the close season had been well timed, as one or two newly-born sea-elephants were seen during the last days of September, and great numbers of males and females were beginning to haul up on all parts of the coast. In the same report the following reasons were given for thinking that there was little fear of extermination under the existing regulations, and in view of the limited number of licences :—

(*a*) The sea-elephants are very numerous, and many parts of the coast are inaccessible to the seal hunter;

(*b*) The rookeries are not disturbed during the breeding season, a great factor; and

(*c*) The seals disperse more or less and take to the water towards the end of February. Also climatic conditions during the winter make sealing a hazardous occupation round a dangerous coast at that time of the year.

The results of the seasons 1912 and 1913 showed that the existing sealing regulations were working satisfactorily, and that the preservation of the sea-elephant was not being imperilled; but, in view of the fact that numerous females with young were seen in the last days of September, that month was included in the close season by regulations dated 29th June, 1914.

Later reports show that the preservation of the sea-elephant was not being endangered, because

(*a*) no decrease has been observed in the number of seals;

(*b*) of the inaccessibility of many parts of the coast, and of the prohibition of sealing on the long stretch from Cape Nunes to Cape Disappointment.

(*c*) of the high expenditure involved in carrying on sealing in these parts, and hence the impossibility of hunting the sea-elephant until non-existent;

(*d*) the yearly licence system enables the Government to prohibit sealing for a period, or to define reserves, if any place is much overworked.

It was also stated that the regulation affecting the female seal had had the desired effect, and the conclusion arrived at was that the results of the previous years showed the "satisfactory working of the regulations, and that the time had not arrived for making any drastic alterations."

Further information as to sealing operations in the Dependencies early in the 19th century, furnished by Dr. Bruce, will be found in the letter read to the Committee at the meeting held on the 30th May, 1918, and in the note of his further remarks to the Committee on the same occasion.*

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* See Appendices I. and II.

3.—Rookeries and Incidence of Seals.

(*a*) *South Georgia.*

(1) *General.*—In his "Voyage towards the South Pole, 1822-24," James Weddell makes the following remarks regarding the seals of South Georgia :—

> "His (i.e., Captain Cook, who explored the island in 1775) official report regarding the island of South Georgia, in which he gave an account of the great number of sea-elephants (called by him sea-lions), and fur-seals, found on the shores, induced several enterprising merchants to fit out vessels to take them; the elephants for their oil, and the seals for their skins. These animals are now almost extinct; but I have been credibly informed that, since the year in which they were known to be so abundant, not less than twenty thousand tons of the sea-elephant oil has been procured for the London market. A quantity of fur sealskins were usually brought along with a cargo of oil; but formerly the furriers in England had not the method of dressing them, on which account they were of so little value as to be almost neglected.
>
> "At the same time, however, the Americans were carrying from Georgia cargoes of these skins to China, where they frequently obtained a price of from five to six dollars apiece. It is generally known that the English did not enjoy the same privilege; by which means the Americans took entirely out of our hands this valuable article of trade.
>
> "The number of skins brought from off Georgia by ourselves and foreigners cannot be estimated at fewer than 1,200,000. I may here also remark the Island of Desolation—(N.B.—Later named Kerguelen Island)—which Captain Cook likewise visited, and first made known, has been a source of scarcely less profit than the Island of Georgia. Hence, it may be presumed, that during the time these two islands have been resorted to for the purpose of trade, more than two thousand tons of shipping, and from two to three hundred seamen, have been employed annually in this traffic."

The sea-elephant, the sea-leopard, and the Weddell seal were the only classes of seal observed at South Georgia during the 1910 season. The fur-seal are believed to have been exterminated about 1874; but Heinrich W. Klutschak, who visited South Georgia in September, 1877, stated that on the bare islands and rocks on the west side of the main island (where the climate is much more severe than on the east) fur-seals were met with and killed in great numbers, both the skins and the blubber being utilised.

(2) *Fur-Seal.*—In 1910 it was reported that no fur-seal remained in South Georgia. One specimen, apparently a casual visitor, was taken in the season 1915, but no further trace of the species was observed. In reporting the killing of this specimen by mistake the Magistrate wrote as follows :—

> "It is remarkable to note that this is the first seal of its kind that has been seen in South Georgia since the commencement of operations in the Dependency."

It is now suggested that an attempt should be made to re-establish the fur-seal in the Dependencies by introducing specimens from rookeries elsewhere in the South Atlantic.

In 1917 the Magistrate reported that no fur-seal had been observed, but expressed the opinion that the fact that none exist could only be established by making a thorough investigation of Larsen Harbour, Drygalski Fjord, and among the smaller outlying islands, such as Annenkov and Pickersgill.

(3) *Sea-Elephant.*—From reports received in February, 1910, it was very evident that hair-seal life was very prolific in South Georgia, more especially the sea-elephant, and that a licence could be granted without any fear of extermination. As the hair-seal is principally killed for the blubber it is very difficult to restrict the take to a given number for this class alone, since a very large number is required to make such a venture pay.

Sea-elephants were reported to be very numerous during 1910; and during the close season (October to January) there were rookeries of various dimensions in most of the bays and harbours visited by the sealers, as well as in other parts.

Nearly all the well-known harbours and bays were reported to be crowded with sea-elephants during the close season 1912.

As regards the year 1913 it was stated that, as at the termination of previous seasons, large herds of sea-elephants had commenced to haul up all along the coast.

and that, at certain parts, never before had such large herds been seen. Numerous females with young were observed during the last days of September, 1913.

Few females were seen in 1914 until the last days of September, when they were very numerous everywhere. Females were observed with pups; and others appeared to be about to bear their young. In a report made in that year the Magistrate stated that he had been assured that, towards the end of the open season and during the close season, there must be thousands of sea-elephants along the stretch of coast (i.e., from Cape Disappointment to Cape Nunes) where sealing is prohibited, and on the neighbouring islands of Annenkov and Pickersgill, large herds having been seen on these latter places.

In November, 1915, the Magistrate visited several of the rookeries and resorts of the east coast of South Georgia, and was astonished to observe the large number of sea-elephants hauled up along the coast. In the smallest harbour, known locally as Little Jason, he counted no less than thirty-seven females each with a pup, and seventeen full-grown males. Further east, at Cooper Island and Green Island, hundreds of male and female sea-elephants were observed. On the former island no less than four hundred females were counted, though there were many more, all with pups. In other harbours seals were observed in almost countless numbers.

In 1916 there was no scarcity in the number of sea-elephants. Large numbers, both males and females, were reported in Division I. The beaches at Elephant Bay and Wilson Harbour were quite lined with both males and females; and the Magistrate, having occasion to visit two of the places (viz., Annenkov Island and Holmestrand) in Division IV., the seal reserve, was astonished to see the huge number of seals along the shore in quite accessible places.

The report for 1917 indicates that there was then no fear of the stock of sea-elephants becoming endangered; and in 1918 the animals were reported to be very numerous throughout the season.

(4) *Sea-Leopard.*—In 1914 it was reported that the sea-leopard was not being killed to any extent, as the animals are of little commercial value, and the value of the skin after preparation does not apparently cover the expenses; hence, these animals are in no danger of extermination. They are very ferocious, and prey on penguins, as well as fish. It is stated that they are never to be seen in large numbers or rookeries.

(5) *Weddell's Seal.*—In the report for 1910 it was stated that Weddell's seal did not appear to be a regular inhabitant of the sea round about South Georgia, although it was possible that in some isolated cases they may breed there. A pair had recently been seen in King Edward Cove.

In September, 1914, the Magistrate observed a small rookery (the only one known in the Dependency) of about thirty Weddell's seals, including young pups of only two weeks old. He considered the doubt expressed in his report for 1910 to be cleared away, and that it could be said with certainty that the few Weddell's seals seen breed in South Georgia as well. The locality of the rookery was given as Drygalski Bay, near Cape Disappointment, and the seals were left absolutely unmolested in any way.

In the report for 1915 it is stated that there could never be the least possible doubt about the preservation of Weddell's seal, as its skin is of little or no commercial value, and that some at least of the seventy-three skins taken during the years 1910-14 were used for scientific purposes.

A small number of Weddell's seals was taken in 1916, but none in 1917 or 1918. In 1917 the Magistrate had requested the sealers to leave this species unmolested unless found in large numbers.

A table showing the catch of the various species of seals at South Georgia is appended to this memorandum.

(*b*) *South Shetlands.*

In the account of his visit to the group in 1823 James Weddell writes as follows:—

> "The quantity of seals taken off these islands by vessels from different parts, during the years 1821-22, may be computed at 320,000, and the quantity of sea-elephant oil at 940 tons. This valuable animal, the fur-seal, might, by a law similar to that which restrains fishermen in the size of the mesh of their net, have been spared to render annually 100,000 furs for many years to come. This would have followed from not killing the mothers till the young were able to take the water; and, even then, only those which appeared

to be old, together with a proportion of the males, thereby diminishing their total number, but in slow progression. This system is practised at the river of Plata. The island of Lobos, in the mouth of that river, contains a quantity of seals, and is farmed by the Governor of Monte Video, under certain restrictions, that the hunters shall not take them but at stated periods, in order to prevent the animals from being exterminated. The system of extermination was practised, however, at Shetland; for whenever a seal reached the beach, of whatever denomination, he was immediately killed, and his skin taken; and by this means, at the end of the second year, the animals became nearly extinct; the young, having lost their mothers when only three or four days old, of course all died, which at the lowest calculation exceeded 100,000."

According to a record in the *Deutsche Geographische Blätter*, 1892, Captain F. Dallmann visited the South Shetlands, the South Orkneys, and Graham Land in 1873-74. He reports that seals were found in the South Shetlands and Graham Land, but apparently not in very great numbers.

Canadian sealers used to obtain (prior to 1904) fairly good catches of from three hundred to five hundred seals. Mention is also made of the capture of some fur-seals about the same period by a Nova Scotian sealer.

On the 23rd December, 1908, one hundred and fifty-five seals, crab-eaters and Weddell's seals intermingled, were counted by the "Pourquoi Pas?" expedition on a beach of Deception Island.

In a minute, dated the 22nd April, 1912, relative to the diary kept by the Customs Officer on board the s.s. "Ronald" during the whaling season 1911-12, the Governor said:—

> "In the matter of hair-seals it is considered that ten thousand might be taken off annually without unduly depleting the rookeries at the South Shetlands. The principal rookeries appear to be at the south-west point of Livingstone Island, on Snow Island, and on the islands of the north-east of the group."

(*c*) *South Orkneys.*

Weddell reported the presence of fur-seals and sea-leopards in January, 1823; three fur-seals were taken; but, as the exploration of the whole group revealed no more, he concluded that those taken had migrated from some land probably not very distant.

In the report on the whaling season 1914-15 it is stated that on Cigney Island (anchorage) large numbers of sea-elephants came up to sleep, and that one season's thinning of the males would not apparently be hurtful to the existence of this animal. A species of seal (probably the sea-leopard) appeared to be in large numbers around this island; enormous quantities of penguins were killed by them, and the remains of the latter littered the sea in places.

(*d*) *South Sandwich Islands.*

Captain Larsen visited the group in 1908, when no fur-seals were found, although five hair-seals were seen on Candlemas, and one on Visokoi.

(*e*) *Other Parts.*

In the records of the "Pourquoi Pas?" expedition there is a note that two or three seals were seen in the pack ice near Alexander I. Land. It is also noted that seals were very scarce in this neighbourhood. In July, 1909, a number of Weddell's seals landed at the expedition's winter station on Petermann Island. These included a female with a fœtus nearly ready for birth. In August another such was observed. A newly-born Weddell's seal was seen in September. The time of birth of crab-eaters and sea-leopards would appear to be later. Two fœtuses nearly ready for birth are noted in September, one being a sea-leopard and the other a crab-eater. A similar note is made in October for a crab-eater.

4.—Licences.

Prior to 1910 no sealing licence had been granted; but in that year a licence was granted for South Georgia and the South Sandwich group, subject to the conditions set out on page 8 of this memorandum. No other licence was issued for 1910.

The Colonial Government, on the advice of the Stipendiary Magistrate, recommended that the coast of South Georgia should be divided into four divisions, for sealing purposes, i.e. :—

Division I.—From Cape Nunes to Cape North.

Division II.—Cape Buller to Cape Saunders (including Bay of Isles, but excluding Allardyce Harbour).

Division III.—Barff Point to Cape Disappointment (including Royal and Sandwich Bays, but excluding Godt Hul Harbour and New Fortune Bay).

Division IV.—Cape Disappointment to Cape Nunes, a distance of seventy miles which made a reserve, sealing being prohibited.

A point of land in Cumberland Bay to the south-east of King Edward Cove, and the waters in the immediate neighbourhood, were declared a seal reserve in 1918.

One licence for each of the Divisions I., II., and III. were granted annually from 1911 to 1917. In 1918 sealing was allowed in Division IV. instead of Division II.

In June, 1916, the Governor reported that in view of need of oil he had instructed the Magistrate to issue an additional licence to a local company, if possible; but no second licence was actually granted.

A licence to take hair-seals at the South Orkneys, Joinville Island, and Graham Land was issued for the season 1913-14. The number of hair-seals to be taken was restricted to ten thousand, and conditions as to the taking of females or pups were attached to the licence; but the maximum of ten thousand was considered to be too high, and the licensee was informed that he had no claim to a renewal of the licence, and that it was unlikely that it would be renewed on the same terms. No report of the working of the licence has been traced.

Statistics of the Catch of Seals at South Georgia.

Season.	Sea-Elephants.	Sea-Leopards.	Weddell's.	Total.	Oil.	Value.
					Barrels.	£
1910	2,965	35	5	3,005	3,467	7,497
1911	1,985	65	9	2,059	4,081	10,077
1912	2,659	87	48	2,794	5,712	14,280
1913	4,503	26	11	4,540	7,840	28,570
1914*	3,070	33	10	3,113	4,641	10,000
1915	2,016	—	1 (Fur.)	2,017	2,537	—
1916‡	2,867	25	14	2,906	5,337	16,000
1917†	2,941	77	—	3,018	5,297	26,485
1918‡	2,952	2	—	2,961	6,137	30,685

* September included in the close season by regulations dated 29th June, 1914.

‡ Sealing allowed specially in September.

H. T. ALLEN.

9th June, 1919.

APPENDIX XV.

THE SEA ELEPHANTS OF SOUTH GEORGIA.

1.—Description.

The following description of the sea elephant was furnished to the Governor of the Falkland Islands in 1910 by Mr. J. Innes Wilson, Stipendiary Magistrate of the Dependency.

"The average length of an adult male is between sixteen and eighteen feet—many have been recorded here to have reached twenty feet—and of the female between eight and nine feet. The most characteristic part of this seal is the shape of the snout. With the young male seal the dilatable part is of normal proportions, but in the newly-born it is hardly discernible, except for a slight horizontal furrow of loose skin between the bony and flexible parts of the nose, which increases in size with age, and finally develops into the inflatable proboscis from which this seal derives its name. This inflation principally affects the skin on the top of the snout, which has a drooping elongation of only two or three inches on a middle-aged seal, but seems to increase slightly as the seal gets old. It is totally absent on the female. The inflation on land occurs when the seal is irritated, or when exhausted after some severe exertion. The pairing commences immediately after the birth of the young, i.e., during the first half of October. The male is not monogamous, as has sometimes been stated,

unless perhaps when driven from the main rookery. During a recent visit to one or two small rookeries in Cumberland Bay I observed one male with over twenty females around him. Other males were lying round the outskirts of the main flock, but dare not approach too near. In such instances the old maxim that 'might is right' is often severely contested by these seals at this time of the year. I was fortunate enough in witnessing such a contest. As the two sea elephants approached each other they emitted low, deep, challenging growls or hoarse grunts; then, closing, they raised themselves on their hind feet or flippers. In this attitude, which showed off their great immensity, and without making any further sound, they silently and somewhat coolly commenced to tear, or, rather, root, at one another's breast. This encounter lasted about five minutes, when the one who had so bravely intruded was gradually driven backwards, and finally had to give way to his more powerful antagonist, and hurriedly crawled away to add another to the vanquished. During the fight I observed that the inflated proboscis appeared to be often in the way, and both seals had very severe cuts at the end of that organ, as well as great tears down the side of the neck and breast, from which they were bleeding profusely. Many of the female seal appear to be absolutely careless of their young, giving the impression that the death-rate amongst the young seal must be considerable. Also, when an angry male observes an enemy, he does not by any means study which course he will take to reach the intruder, but tears along over mother and young, and to the terror of the whole flock, which does its best to open up a way for their jealous and infuriated protector. It has been well said that when this animal moves 'the vast body trembles like a great bag of jelly, owing to the mass of blubber by which the whole animal is invested, and which is as thick as it is in a whale.'"

The statement in this report relative to the death-rate amongst young seal was confirmed by Mr. Wilson in a later report, dated 12th November, 1912, in which he stated that a considerable death-rate was observed among the newly-born seal owing to the carelessness of the parent seal.

In an article entitled "A Desolate Island in the Antarctic," which appeared in the *American Museum Journal* for October, 1913, Mr. Robert C. Murphy said that, as nearly as he could determine from his observations filled out from the accounts of experienced sealers, the life history of these animals is very briefly as follows:—

"The single 'pups' are born on shore in early spring (September, October), and the old ones pair immediately afterwards while the young are nursing. For a period the adults then lie ashore, moving little, and, of course, feeding not at all, while they grow gradually thinner, supporting life upon their own plenteous blubber. The pups are more active, frequently entering the water and playing with one another in schools. They seem to be weaned at an early age, probably during November. After six or eight weeks the mature animals go into the sea, where they feed, and may journey hundreds of miles, but on this part of their lives there is a gap in our information. A few slothful individuals continue ashore, and I have seen bulls of this sort in a state of pitiful emaciation, lying in wallows, either alone or with four or five cows, as late as 1st March. Early in January well nourished adult sea elephants begin to 'haul up' from the sea again, and, as the month advances, considerable herds of exceedingly fat females gather on the upper beaches. The males come later, during February and March, and are then of enormous bulk and are very lethargic. These are the March bulls, which sealers prize, for one such may yield five or six barrels of oil. They locate wherever they can find company, and, if undisturbed, remain in sleepy ease throughout the remainder of the Antarctic summer and the autumn. During the winter they divide their time between the land and the adjacent waters, and are in prime condition when they come ashore to stay during the breeding season of the following spring."

In the same article Mr. Murphy expressed the view that, the sea elephant being slow, unsuspicious, and gregarious, can be hunted profitably until the last one has gone to his ancestors. This opinion was controverted by Mr. Wilson on the ground of the high expenditure necessary for carrying on either sealing or whaling in the Dependencies.

The seasonal reports on the sealing industry show conclusively that the seals commence to haul up in September, the males preceding the females; and there seems no doubt that the animal is polygamous. It also appears that pairing commences immediately after the birth of the young, i.e., October. During the close season 1913 the sea elephants were reported to be very numerous everywhere,

including the Bay of Isles, etc., and it is stated that in this particular locality they all seemed to go away just after they were big enough to look after themselves, which would be some time in January.

2.—Statistics of Sex Distribution.

Figures as to the numbers and sexes of the animals comprising various herds are found scattered through the seasonal reports, but are not sufficiently detailed to throw any conclusive light on the question of the number of females in an average harem or the proportion of young males and idle bulls to harem bulls. The following figures may, however, be of interest. In the report by Mr. Wilson quoted at the commencement of this memorandum he states that he observed in Cumberland Bay one male with about twenty females around him, and that other males were lying round the outskirts of the main flock but dare not approach too near.

In September, 1914, at one place in Royal Bay, a flock of thirty full-grown males and six females was observed. At Queen Maude's Bay, on the 30th of the month, twenty-six full-grown seals (males) were taken, ten females being also seen lying near at hand. On the north-west side of the bay a number of males and two females were observed.

At one place in Cumberland Bay, on the 15th October, 1914, fifteen females were seen with one large male and two or three other males in the locality. Eight of the females had pups, while two or three appeared to be about to bear their young.

It should, however, be remembered that the figures for September are scarcely a safe guide as to the relative proportions of the sexes, since at the end of that month many females have not yet hauled up, and the male elephant at this time is constantly on the move.

In November, 1915, thirty-seven females, each with a pup, and seventeen full-grown males were counted in a small harbour on the north-east coast of South Georgia, known locally as Little Jason; further east, at Cooper Island, no less than four hundred females were counted, though there were many more, all with pups. There were also some hundreds of male elephants scattered about, some in the water and a few on shore.

In a report for 1916-17 it is stated that, on a point in Cumberland Bay which contains tussock grass in abundance and makes an excellent breeding place, there are generally in the season from sixty to seventy females and some twenty to twenty-five males.

On the principal beach of the Bay of Isles in November, 1917, fifty-two large bulls, ninety-six females, and many hundred of pups were counted. At other ports of call on the same trip the following counts were made:—

	Place.	*Males.*	*Females.*	*Pups.*
Division I.	Else Cove	23	3	3
	Wilson Harbour	49	63	numerous
Division III.	Green Island	46	57	numerous
	Gold Harbour	134	285	750
	Royal Bay	77	142	over 1,000
	St. Andrew's Bay	192	338	over 1,000
		521	888	

At Royal Bay and St. Andrew's Bay it was quite impossible to arrive at any number of pups. The magistrate counted up to one thousand, and was quite sure there were as many more scattered about the beach. Those counted were in the fresh-water stream. The majority were without the mother, and looked in very good condition. A good number of them had already taken to the sea. At the latter place much fighting was observed among the males. The older males were guarding the remnant of females left on the beach; while the younger were all in the water and not permitted to land. Out of one hundred and ninety-two counted there were only about eight or nine among the females on shore; the magistrate thought at the time that it would have been much more beneficial to the herd if about one hundred and fifty of the males had been killed.

In the same report he expresses the view that sealing could be carried on throughout the year and treated in the same manner as a cattle or sheep farm, only allowing the older males to be killed, with a condition that at least one male be left on the beach to every twenty-five females. "As there is not the smallest

doubt of the sea elephant being polygamous there need be no close season. I feel sure, from my observations and experience gained since my arrival in South Georgia, that if this were permitted, instead of there being danger of extinction, it would have the effect of advancing the stock." As regards the magistrate's analogy of a cattle or sheep farm, it may be mentioned that, in the lecture referred to below, Professor Parker states that the fur seal herd (i.e., of the Pribylof Islands) is open to the same kind of management as chickens or cattle.

3.—Disturbance of the Rookeries.

In the report furnished to the Governor in May, 1914, the magistrate wrote as follows:—

> "I remember on one occasion with the late Major Barrett-Hamilton being able to visit a reserve sea elephant rookery at Husvik Harbour (the conditions of the sealing licence do not permit the licensee to seal here), three miles from the whaling station. It was a small rookery, but the beach there was covered with the current season's young, and there I saw crowds of working men also visiting the rookery and enjoying the diversion from their otherwise monotonous confinement on the whaling station. This rookery has been there for many years, certainly before the whaling companies came there, and that is about seven years ago. It does not in any way appear to have suffered from the continued presence of man, nor have I seen any signs of a breach of the law for their preservation round this quarter. I merely mention this particular case to show that the local protecting laws are respected by the usual habitué of the Dependency."

In a report on a tour of inspection undertaken in September, 1914, it is stated that the continual disturbance at various resorts and rookeries does not appear to affect the seal. Unlike the sea lion or leopard, he takes no notice of a gun, and when driven is more inclined to move inland than to make for the water. On the other hand, Captain C. Rasmussen, of the steamship "Undine," the sealing ship of the Cia Argentina de Pesca, stated that he had always found fewer seals in Division II than on the other side of the island in Division I, and that he thought whale boats may have something to do with this, as they all operate from the north-east coast.

4.—Conclusion.

The evidence adduced shows that the sea elephant is a polygamous animal, and indicates that, in general, its characteristics in this respect resemble those of the northern fur seal. At South Georgia the animals commence to haul up for breeding purposes towards the end of September, though it is possible that the time may vary according to climatic conditions. Pairing again takes place in the following month after the birth of the young. The pups are apparently weaned in November and become ripe for an independent existence by January. There is also evidence that the animals disperse more or less and take to the water at the end of February, from which month until August or September they are away from their usual haunts; the few that may be found lying along the shores being poor in condition. Mr. Murphy speaks of well nourished specimens hauling up in January and February, and also refers to specially prized "March" bulls; but the last seasonal report speaks of the seals found in January and February, 1917, being inferior in condition. An examination of the seasonal reports shows that the favourite months for sealing operations are January, February, and August, and September also when allowed in that month, which is now normally included in the close season.

In a further article by Mr. Murphy, published in the *Scientific Monthly* for August, 1918, he states that, "at South Georgia persistent killing pushed (the sea-elephant) so near the verge of utter extinction, that in 1885 the crew of a Connecticut schooner during the weeks of the breeding season (September to January) was able to find only two of the animals. From before that date, however, until after the beginning of the twentieth century, the seat of the "elephant oil" traffic was transferred from the South Atlantic to the fresher islands of the Indian Ocean, and so the species was given opportunity partially to regain its foothold at South Georgia." In his earlier article Mr. Murphy suggested that this local scarcity recorded in 1885 may perhaps have been an example without a parallel; and it must also be remembered that sealing operations at South Georgia have for many years been carefully regulated by the Colonial Government. A Sealing Ordinance was passed in 1909, and, as since 1905 the island has been the seat of a whaling industry, the possibility of illegal sealing remaining undetected has been much diminished, if not eliminated. Under the present system of protection, and with the strict limitation of the issue of licences, the sea elephant

has multiplied exceedingly. In these circumstances it is arguable that no change in the present system of protection is necessary; but the apparent resemblance between the sea elephant and the northern fur seal in their polygamous habits suggests consideration of the question whether the system adopted in the case of the latter might not profitably be adapted to the former. There is, however, from the economic point of view, a fundamental distinction between the two species, inasmuch as the fur-seal is taken for its skin, that of the young males being the most valuable, whereas the sea-elephant is pursued for the oil which it contains, the largest males being, therefore, of the greatest economic value.

In a lecture on "The Growth of the Alaskan Fur Seal Herd between 1912 and 1917," read by Professor G. H. Parker before the National Academy of Sciences on the 23rd April, 1918, he said that "eventually, as numbers augment, the beaches on which breeding occur will become overcrowded, shortage of food may supervene, epidemics due to unfavourable conditions may appear, and these and other like influences will cut down the rate of increase until the herd, having arrived at its maximum number, will stand at a constant level." Mr. Parker also points out that recent rapid increases in the number of idle bulls constitute "the one unfavourable feature in the recuperation of the herd, for it marks the effective appearance on the beaches of the first real element that is detrimental. Fortunately it is within reasonably easy control . . . . the sexes are approximately equal at birth and . . . . although good management calls for a careful rearing and preservation of females, it also demands the retention of only such males as are necessary for breeding, the excess being drawn off for market purposes. . . . It may be stated that since 1912 the steady increase in the number of pups born and of harem bulls, and the decrease since 1913 of the average harem, are most favourable signs of the growth of the herd. The one unfavourable feature during this period is the considerable increase in idle bulls in 1915-1916, and especially in 1917. This increase, which can be eventually checked, shows that active commercial killing should have been restored some years ago."

The enormous increase in the number of sea elephants observed at South Georgia in recent years suggests that the considerations urged in regard to the Alaskan fur seal may on investigation be found to apply with equal force to the herds at South Georgia. The adoption, if feasible, of some such system as that in force at the fur-seal rookeries at the Pribylof Islands might increase the economic value of the seal oil industry at South Georgia, and yet, while not involving any diminution in the number of sea-elephants taken, prove a positive advantage to the herds. It is even possible that increased killing on a scientific basis might safely be allowed; and, in addition, the abolition of the existing close season would increase the economic value of the industry in view of the better condition of the animals and the greater yield of oil during that period.

But an expert investigation of the rookeries is a condition precedent to any consideration of a drastic change of policy. Such an investigation will presumably form part of the work of the biologists of the proposed research expedition; and, in the meantime, there seems, with the maintenance of the existing system, little reason to be apprehensive of danger to the stock of sea elephants in South Georgia.

H. T. ALLEN.

30th September, 1918.

APPENDIX XVI.

NOTE ON NECESSARY INVESTIGATIONS ANCILLARY TO DIRECT RESEARCHES UPON ANIMALS OF ECONOMIC IMPORTANCE.

1. The acquisition of fuller knowledge as to the life history, distribution, and movements of the animals of ecomonic importance to the Dependencies of the Falkland Islands is clearly essential for the development and regulation of the industries based upon these animals. Collection of reliable statistics of capture, and researches dealing with the species taken commercially must, therefore, have precedence in any inquiries recommended by the Committee over any work other than such hydrographic surveys as reasonable safety in navigation requires. It will be generally agreed, however, that both development and regulation may be expected to become progressively more efficient and more confident as the conditions resulting in the facts established in the direct researches gradually come to be understood.

To know in some detail the usual migration of the humpback, for instance, would be much, but if, in addition, the migration could be correlated with certain easily ascertained conditions, far greater confidence could be felt in the interpretation of apparent abundance or scarcity in a given region in terms of depletion of stock, economy of search might be secured for whalers, and to mention a very distant, but still legitimate, aim, the time of commencement of the season might be anticipated and its character foretold. Ancillary researches thus become necessary, and it is necessary to find the main lines these should pursue.

2. Whaling and sealing are seasonal in character, either as a whole or as to locality, and they fluctuate from year to year; probably fisheries, should any develop, will be similar in these respects. Moreover, in the statistics which have been collected concerning the whaling operations, a certain amount of fluctuation in the catch can be observed. This is brought out most clearly by expressing the captures as numbers of whales caught per vessel. The figures given in Appendix V., so treated, furnish the following table for the South Georgia returns :—

Year	No. of Vessels.	Number per Vessel.			
		All Species.	Humpbacks.	Finbacks.	Blue.
1909-10	17	207	200	3	2
1910-11	19	343	326	9	4
1911-12	21	311	268	25	14
1912-13	21	231	112	103	15
1913-14	21	159	24	82	45
1914-15	22	232	37	88	105
1915-16	24 (average)	306	65	114	126
1916-17	32	140	12	50	76
1917-18	32	100	2	36	58

3. Treating first the whales without distinction of species, it will be seen that from 1910 to 1912 were years of successful whaling, and that from 1914 to 1916 a partial return to a similar degree of success was attained, while in years immediately succeeding or preceding these years and intervening between them catches are less abundant.

4. Comparison of the figures for the three chief species stated in the other columns shows that the predominance of catch has passed from the humpbacks to the larger whales, but it is important to notice that the decline in the catch of humpbacks per boat has not been continuous. Bearing in mind the greater value to the whalers of the finbacks and blue whales compared with the humpbacks, the search for humpbacks can hardly have been more severe in the case of an average whale catcher as time went on, and it would, therefore, appear that depletion of stock is, at all events, not the only factor to which a decline of humpbacks in the catch is due. The most noteworthy feature is the similarity in the change from year to year between the catches of any two species, since the number of the species concerned has risen to a considerable figure. Thus, between the seasons 1912-13 and 1917-18, a fall in the number of finbacks taken was accompanied by a fall in the number of humpbacks, and a rise similarly accompanied by a rise in the latter species. Similarly from the year 1913 to 1918, the catch of blue whales varied always in the same direction as that of the other species. The changes are clearly not to be explained as being due to a sharing of an approximately constant catch among different numbers of vessels in the various years concerned, since from 1913 to 1917 the number of whale catchers employed continuously increase and, as has been seen, the catch of whales fluctuated. The rise in the number of humpbacks taken from 1913 to 1916 (although small), since it is contemporary with a slight increase of finbacks and a very large increase of blue whales in the catch, would appear to indicate that the whalers do not neglect the capture of the first-named species, at all events with any approach to completeness in their pursuit of the more valuable whales. The whole period included in the records is not great, but it is sufficient to show strong indications of a fluctuation of abundance from year to year in the whales to be found off South Georgia, irrespective of any depletion of a given species owing to the operations of the whalers.

5. The causes for these changes, regular and irregular (apart from any depletion traceable to man), must be sought in the animals' environment, and, in view of the wide area covered, the field is admittedly immense. Nevertheless, if knowledge of the facts underlying the industries are to pass out of the empiric stage, subsidiary

researches are essential; and the magnitude of the task makes it the more desirable to observe due proportion in pressing the various possible lines of work, and endeavouring by arrangement to get the utmost result of the efforts made.

6. The fisheries of north-west Europe parallel in many important respects the industries of the Dependencies. They are carried out similarly in high latitudes, conditioned by a certain measure of abundance of the species taken, fluctuating in success, while fears have been widely entertained that these species were in danger of the gravest depletion by the destructive action of man. Owing to the importance of these fisheries they and the attendant circumstances have long been the subject of the most diverse researches, including in their operation the most refined oceanographic methods, and even the widest oceanographic exploration. It may, therefore, be instructive to consider briefly the nature of the main lines of work carried out, and then to see how far these are applicable to the purpose in hand.

7. In addition to the researches upon the actual food species, these investigations have dealt with the fauna of the sea bed (or benthos), the floating fauna and flora (or plankton), the marine deposits, and the sea water in respect of composition, properties and movements.

8. The most important features of the deposits from a fishery standpoint are, that various food species are found to frequent ground of certain texture—for various causes, but principally as being the home of species serving the fish as food—while in the vicinity of coasts the organic detritus, even when settled and forming part of the deposit brought down by rivers, has been found to constitute in itself a food for certain groups of animals, edible shellfish included. The importance of the benthos from an economic standpoint is that members of it either are edible species or form their food. Deposits have been collected in these studies by various instruments, some capable of bringing up very large samples. The chart shows, however, that, while ground of less than a hundred fathoms surrounds the various groups of islands and borders Graham Land, compared with the water area of even the Dependencies alone, this ground is of small extent, the depth rapidly decreasing to over one thousand fathoms, while much of the sea in the area is more than twice as deep. Two industries have to be considered, whaling and fishing. Should valuable accumulations of fish be found, and their exploitation prove worth while, there is a probability that investigation of the relatively narrow banks, both as to deposits and benthos, would prove profitable; in regard, however, to whaling the bearing of this work would appear remote. Similar work in the deeps is unlikely to assist in the elucidation of seasonal phenomena, such as whale migration, the seasonal changes so far recorded in the great depths being but slight. This is not to say that the benthos or deposits in the deeps are without influence on the superficial water layers; probably for some distance down the slopes rooted forms send up larvæ which form a considerable addition to the plankton, and from even greater depths it has been conjectured that nutritive substances which have been carried down from the surface layers by animals are returned to them in certain current systems or in storms; and it is assumed that small samples of the deposits will invariably be collected in the course of sounding. Nevertheless, the work on benthos and deposits may be regarded from an economic standpoint, except in the coastal banks and in relation to fisheries, as rather an activity to be followed as the other work permits than one to be given prominence. It cannot, however, be too strongly urged that such opportunities as this affords should be utilized vigorously; it is impossible to feel any confidence in the treatment of a marine problem without a good general grasp of the conditions in the background.

9. The plankton of the European seaboard has been studied not only for its theoretical but for its fishing interest with great assiduity. It was recognized as the chief ultimate source of nourishment for food species, the value of organic detritus from the land being almost ignored until attention was recalled to it by Petersen. Immense numbers of records have been compiled, and an elaborate technique of methods and apparatus developed for both its collection and examination. The identification of species, their distribution and abundance, and the conditions governing these, have alike been the subject of a great volume of work. The commonest method of determining abundance was by enumeration, and this was soon refined by the use of standardized nets, calculation of the filtration effected by them, and standardized sampling of catch, these developments being chiefly directed to the attempt to determine the absolute quantity of a species, or

of the whole plankton present below a given area of water or in a given volume at a particular depth. The most interesting results from the present standpoint were the discovery developed by Cleve and others, that certain species characterized water of given physical characters and from a given source of supply, the chemical work such as that of Brandt upon the limitation of production of certain species by the quantity of a given necessary substance in the water present —one of the most suggestive of plankton researches—and the determination of spawning grounds of fish by the abundance of floating eggs. Totally inadequate as is this outline of some main divisions of plankton research, it is given as enforcing to some extent the immensity of the field, and the grave danger, therefore, of working industriously in it without any early or immediately relevant result. The mere work of identification and enumeration of specimens is a very heavy one, even if carried out for a few fixed stations only, and restricted to the larger forms.

10. Nevertheless, the importance of the plankton in the Antarctic may reasonably be assumed to be of the highest order. It must form, to an even greater extent than in or near the Arctic, the source, practically the sole ultimate source, of food of all marine animals, and by consensus of opinion a direct food of many whales. Plankton research must, therefore, be undertaken, but a deliberate choice made of a few lines of work in the first instance. Great as is the interest of such chemical work as that instanced above, it will be wise not yet to embark upon it. The attempts to determine the absolute organic content—and the methods adopted have been subjected to the most damaging criticism—must also be left in abeyance; there is, on the other hand, a great advantage to be gained by the use of nets of standard mesh, utilization of water samples, the pumps and centrifuges, the definite methods of "diluting" the catch, which, having been used so widely, afford comparable data—even also the culture methods employed by Allen. Unfortunately no really satisfactory estimate of quantity except by counting appears to have been developed, especially where, as here, the aspect of the plankton most important is that of food. Some rough but useful information may be afforded by volume or dry weight, but enumeration must clearly be carried out. The proper course would, therefore, appear to be to confine attention otherwise to such species as shall be found to form :—

1. The food of animals economically important;
2. The chief food of animals on which animals of economic importance largely feed; also
3. To any forms suspected of characterising certain water masses; and
4. To fish eggs and larval fish.

I suggest, therefore, that the first step should be to determine these species—which can probably be carried out largely by vestiges in stomach contents, and the second, to attempt to map their distribution bathymetric and horizontal, and in relation to the character of the water. In addition, however, the record of characteristic species might furnish useful information of a supplementary or corroborative evidence as to current movements, though such evidence would neither be the most direct nor altogether conclusive. The importance of the fish eggs and young fish would depend, naturally, on whether fish are exploited or are found (as in the case of the Lodde, *Mallotus villosus*, in the north) to furnish a chief food for larger fish or for whales.

11. In thus limiting the inquiries, perhaps, at first to the first two items mentioned, it must, however, be remembered that general collections will be made in the course of the work which, from the scanty material hitherto obtained from the extreme south at least, would probably find a welcome from many planktologists, and, as far as the prosecution of the work permitted, it would be most desirable to preserve and despatch such material to specialists for the general purposes of science, which would ultimately no doubt prove of practical value also.

12. The great importance which fishery investigators have attached to hydrographic conditions is due principally to the fact that, being subject to seasonal and other periodic changes, some regular, some apparently irregular, hopes were naturally entertained that, if sufficiently understood, they would furnish explanations of the success and prospects of fisheries, themselves seasonal and fluctuating. It is in fact by hydrographic observations, at the appropriate depths, that the seasons of the sea (which are not necessarily those of the air), are determined; and temperature determination ascertained with great accuracy and carried out with the utmost care, both of instrument construction and of calculation, is naturally

essential. How great the direct effect of temperature is at times is most remarkable. Hjort mentions that in the Barents Sea, the seat of very sudden changes of temperature, millions of capelan (or lodde) are occasionally seen drifting about dead, and ascribes their destruction to such a sudden change; and, as he remarks, the destruction to young fish and eggs is probably greater than among adults. When it is remembered that the lodde forms the food of large shoals of cod, and that these are preyed upon by seals, the relevance of the instance is clear.

13. It is necessary, therefore, both to know and to understand the temperature distribution. The heating by direct warming action of the sun penetrates but slowly, and, indeed, Helland Hansen quotes a calculation to the effect that, in a deep sea, water at 0° in contact with a heating agent 30° higher in temperature would not be appreciably heated by convection at a hundred meters in a hundred years; and, while some convection is caused in winter by the surface layers rising in density as they cool, this convection is strictly limited in the depth it affects. Temperature changes are thus transmitted practically entirely by the movements of the water convection, either superficial or submarine waves, or the movement of great water masses. Of these the last-mentioned is by far the most important.

14. Even for the study of temperature, therefore, the tracing of the movement of water masses is necessary. Valuable as are observations by current meters, they are delicate and prolonged operations, and for this purpose they are supplemented very greatly indeed by the chemical examination of water samples. The proportion of common salt to the other salts present in sea water being practically constant in the open sea, the total salinity is determined on the basis of an estimation of the quantity of chlorine present in a known volume. This quantity is found by titration, and, while great accuracy is necessary, the operation is brief. It is practicable, therefore, to carry out great numbers of such determinations, and to trace the intrusion into fresher or salter water of a given current. For many purposes the results are more useful than those obtained with meters; for with the water will come the plankton and any larger animals seeking it for food—possibly also some unknown and important substance in minute but essential proportions—and by plotting salinities the continuity of a water mass from front to source is in principle simple to trace.

15. A classical instance in which hydrographic conditions were called in to explain the fluctuations of an industry is that of the West Swedish herring fishery. This fishery, which is of great antiquity, is marked by very great irregularity, in some years being practically a failure. The work of Ekman and Petersen demonstrated that the water in which the herring were taken was of a definite narrow range of salinity, intermediate between that of the water of partly Atlantic origin which formed the bottom layer in the central part of the North Sea and Skager Bank, and the fresher surface stratum. When the water favourable to the herring was forced into the fjords and lay over the bed of these and the coastal banks at the proper season the fishery could be prosecuted; if, however, the water failed to arrive, so that the colder Baltic water formed the bottom layer, or if the "Atlantic" water pressed in, squeezing the overlying bank water (as the favourable stratum was called) into a thin sheet beneath the fresher surface layer, the fishery failed.

16. It will be seen by this example that, in the explanation of an economic event study of a whole system of layers is involved, and that this study was carried out by salinity determinations, though, in certain more recent developments it is true that ingenious recording instruments have since been used. It may be thought that the influence of changed hydrographic conditions might be confined to shallow and involved waters, such as those of the Kattegat, where changes can be sudden and produced by comparatively slight cause, such as winds of short duration; this, however, is not the case. The whole of the waters covered by the fisheries, reaching to Iceland and the Barents Sea, are affected by the translation of water masses, in surface streams of great extent and thickness, to whose ebb and flow the cycle of fishing operations seems related. Currents of Atlantic origin reach the Murman waters, and upon them, in the opinion of Russian investigators, the fisheries of that region depend. In fact, for the main factors in the determination of marine seasons in these seas it is necessary to refer to the contributions of Atlantic and polar water, even more than to water from the land or to land conditions, and to explain them an adequate understanding of the main Atlantic circulation will be necessary. There are strong indications also that, directly or indirectly, differences between the dates of waxing of the Atlantic contributions in different

years are related to the success of certain open sea fisheries, and to the distribution of seals. It is at all events clear that, with the definite nature of the hydrographic conditions suitable for spawning, not only of fish, but even of important plankton organisms, such as *Calanus finmarchicus*, the year's contribution to the stock of a species must be at the mercy of hydrographic conditions, while the transport of eggs and larvæ to fatal or favourable localities, as the currents direct, accentuate this relation. In view of Dr. Hjort's classical researches into the age constitution of shoals, and his demonstration of the dependence of abundance in great measure on the contributions to stock made in particular years, this point is of immense importance, both in regard to the species concerned and those dependent on them for food.

17. It is thus probable by analogy that, for the elucidation of conditions in the waters of the Dependencies, information as to the movements, characteristics, and relations of water masses are essential, and almost as certain that this information will be found to demand in turn knowledge of the main South Atlantic masses and their movements; and I would suggest that to hydrographic researches be given priority of place in the ancillary researches to be recommended.

18. A most instructive summary of the existing knowledge of the main oceanography of the South Atlantic is given by Helland Hansen as an appendix to Amundsen's "South Pole." It is based in part on preliminary results from the material and observations taken by the "Fram," and, in Helland Hansen's opinion, this mass of data exceeds that of all previous expeditions in the region. Two complete sections of the ocean were examined, between the latitude of Buenos Aires and Rio Janeiro, sixty stations being worked. In his description and charts the isotherms show that the Brazilian current is naturally warmer than the Benguela, while the course taken by Antarctic water results in the isohalins also being further to the north on the African side than on the American; but the Benguela current becomes more saline owing to evaporation as it proceeds. Parenthetically, there is between it and the African coast a belt of fresher water. That part of the equatorial drift which forms ultimately the Brazilian current receives but small additions of fresh water by precipitation, and the surface salinity rises, the saltest water in the whole South Atlantic being found in the northern part of this current. Further south the La Plata sends out an immense volume of water (fresh), which, owing to the rotation of the earth, mainly trends to the north. These, with the Falkland current, are the main factors for the surface circulation.

19. Salinity and temperatures do not vary greatly over 75-150 metres depth. Below this both decrease rapidly for some distance. At 400 metres there are bands and islands of warmer water than either north or south, stretching eastwards over the stretches of coast beyond Buenos Aires and Rio; this reaches twelve-thirteen degrees as against seven-eight on the equator. This warm region is the centre of the main circulation of the South Atlantic. Throughout the belt high temperatures, and accordingly in the main light water, are on the left-hand side of the current, and low on the right, which is an effect of the earth's rotation.

20. The effect of the earth's rotation in the southern hemisphere is that the light water from above is forced somewhat down on the left side of the current, the heavy cold water from below is raised somewhat. Below 400 metres the temperature decreases rapidly down to 1,000 metres, and then very slowly—conceivably in the absolutely lowest layer there is a very minute rise.

21. The South Atlantic is divided by a ridge north and south, terminating near Iceland, and by another east and west between latitudes 25° and 35° S. There are thus four deeps, the Brazilian and Argentine on the west, and West and South African on the east, and the bottom water in these is found to vary. In the two western deeps the temperature is only a little above 0° centigrade; the same temperature is found in the South African deep, and further eastward in a belt which is continued round the whole earth. To the south between this belt and Antarctica the temperature is much lower; but in the East African deep it is 2° higher, resembling the temperature of the North Atlantic bottom strata. The explanation appears to be that, in the last-named deep the source of the water is northerly, in the rest it is southerly, and Hansen ascribes this distribution to the earth's rotation.

22. Salinity also decreases to 34-34·5 per mille at 400 fathoms, rising to 34·7 in the bottom water of the southern region, and to 34·9 in that further north.

23. The fresh and cooler character of the Benguela current is maintained down to 500 metres; thereafter it decreases.

24. The sections actually plotted show undulating isohalins and isotherms. These are considered to be due possibly to submarine waves (which may reach 100 metres in height), and to the depression and elevation of the two sides of the two currents due to the earth's rotation, but chiefly to eddies. The similarity of conditions in the surface layers usually extends to 100 metres in the winter, and is due to convection. The calculation is made that cooling of the South Atlantic lying between 15° and 35° S. latitude, bearing in mind the depth to which convection reaches, and, taking the average cooling as 2°, would be sufficient to warm the whole atmosphere of the earth through a similar range of temperature. The effect of the sea on a climate should in Helland Hansen's opinion be of great assistance in forecasting the latter.

25. The "Valdivia's" expedition has given ground for supposing considerable variations, even in deeper seas below 500 metres in the neighbourhood of the African coast. The "Planet," in 1906, working near St. Helena, obtained considerably greater salinities than did the "Fram," and since the current here may be considered a continuation of the Benguela current, it is possible that this current may suffer variations, perhaps annually, and due in turn to differences of precipitation or Antarctic water. The paper concludes :—

> "We require a larger and more complete material for comparison; but even that which is here referred to shows that there may be considerable yearly variations, both in the important, relatively cold Benguela current, and in the currents in other parts of the South Atlantic. It is a substantial result of the observations made on the "Fram's" voyage, that they give us an idea of great annual variations in so important a region as the South Atlantic Ocean. When the whole material has been further examined it will be seen whether it may also contribute to an understanding of the climatic conditions of the nearest countries, where there is a large population, and where, in consequence a more accurate knowledge of the variations of climate will have more than a mere scientific interest."

26. It is clear from this brief account that even at present the known differences between water masses and their movements with their burden of plankton are suggestive as possibly furnishing most important factors in determining the locus of the schools of whales, as of congregations of other animals, from year to year, as well as in their seasonal migrations. Their bearing on fish is probably even more direct and marked. The area concerned, however, is vast, and in much of it fitting weather for observations is at least not general. To keep the operations within manageable compass will, therefore, be almost as difficult as their omission would be serious. Two points immediately occur; one is that the utmost efforts should be made to utilize the work of others besides the special investigators at work, the other to endeavour to restrict the work to the more immediately profitable in the first instance.

27. In regard to the first point, it will be noted that, in winter, owing to convection, the water in the south of the South Atlantic is practically homogeneous for some 150 fathoms. Surface observations will accordingly apply in this season, particularly to an extensive layer of water, containing a very large amount of plankton; and it is most desirable that arrangements should be entered into with Buenos Aires, Rio, and Cape passenger lines from British, Mediterranean, and North American ports for the compilation of surface temperature records and the collection of water samples for analysis in the researches by the staff or the Government Chemical Laboratory. There is no question as to the practicability of this procedure, since it is already largely employed in the North Atlantic. It should be extended to whalers; a small payment and a systematic policy of keeping masters in touch with any outcome of the work on the material would probably prove a better aid to effective collection than inclusion of provision for the work in any future licences. In addition, full advantage should be taken of the standardization of methods and amassing of comparable data from the North Atlantic and Arctic by working in full touch with the International Council for the Investigation of the Sea, which has now for many years successfully co-ordinated the fishery researches of north-west Europe, and in whose deliberations the United States authorities assist.

28. The restriction of researches is not a matter on which it is possible to pronounce beforehand, except that the simple salinity and temperature determinations and their collation should at least with current measurements constitute the whole of the hydrographic work other than those of Admiralty survey. In regard

to distribution of observations, water samples can be taken wherever opportunity permits; and serious efforts should be made to test, and, if satisfactory, employ a full speed water bottle capable of working at moderate depths. Experience should show shortly with what intervals in a vertical line observations can be made in a given area without misleading results; and so that continuous sections in the waters of the Dependencies may be secured advantage should be taken of cruises carrying out lines of soundings, to run series of stations rather than to work stations sporadically. Lastly, it is of real and vital importance that the quick working up of results may be effected, for the quick progress and the success of the work will depend very largely on the progressive guidance of preceding work.

29. It will be seen that the salient features of the researches ancillary to the direct inquiries dealing with the species of economic value appear to the writer to be (1) that they hold the key to the understanding of the problems of development and regulation, and (2) the great diversity and vast scope of this subsidiary work with the consequent danger of attempting more than could be achieved. The suggestion here made to the Committee is that, notwithstanding the admitted difficulty of combining a broad policy in research with relatively small equipment, an earnest effort be made by a process of selection to recommend the prosecution of fundamental researches which are yet not impracticable for the means employed. Admittedly, further sifting (as well as some additions), may prove desirable, as the work goes on; but knowledge of researches along the lines detailed seem essential to an adequate treatment of the industries.

J. O. BORLEY.

May, 1919.

APPENDIX XVII.

NOTE ON THE POSSIBILITY OF DEVELOPING FISHERIES IN THE DEPENDENCIES OF THE FALKLAND ISLANDS.

The possibilities of developing a fishery depend upon (1) the existence of adequate accumulations of edible fish to permit of profitable commercial working, (2) the existence of available markets, and (3) the employment of suitable means of capture, preservation in its broadest sense, and transport.

1.—The Location of any possible Fishing Grounds.

There are many general considerations leading to the expectation that workable accumulations of fish can be found. The total means of supporting life in the colder seas are well known to be greater than those in tropical waters, and by analogy of the northern hemisphere it may be expected that the chief fisheries of the southern hemisphere, where conditions of depth are suitable, will develop roughly in the latitude of the Dependencies, although, taking the physical conditions as a whole, the Dependencies should be somewhat on the southern border of the zone of greatest abundance. The configuration of the sea-bed and certain hydrographic characteristics of the ground between the Falkland Islands and the south-eastern coast of South America, for instance, would seem to show that the Falkland Islands possess far greater possibilities than any to be found in the Dependencies. The grounds are there at a depth suitable for fishing operations, and such as are known in other latitudes to be the site of large fish populations. The sea temperature is not unlike that on many northern fishing grounds, and the fact that this region witnesses a meeting of currents of different temperatures is again a point which would lead to the expectation that fish would be obtained. Nevertheless, the fact that the waters of the Dependencies support quantities of seals and penguins makes the existence of at least a fairly large fish population probable. Direct observation has shown, moreover, the presence of edible species, chiefly *Nototheniidae*, while shoals of fish resembling small herring are reported from Port Stanley, and may well stretch farther south. A useful body of information as to the actual species found to date exists, and has, I understand, been summarized for the use of the Colonial Office by Mr. C. Tate Regan, F.R.S.; but, valuable as existing information is, a perusal of the accounts of expeditions to the Antarctic shows that no investigations have been made with gear which could be trusted to furnish an indication of workable accumulations of fish. It may be mentioned, as an extreme instance, that at Hope Bay, Dr. Nordenskjöld employed a hook made out of the handle of a pocket knife, and, later, one made from a shoe buckle; but, leaving aside such improvisations, the gear used by the exploring ships has always been of small collecting power.

It is most desirable, therefore, that a survey should be made of all the probable sites for accumulations of fish, in the first instance, naturally in the shallow waters, limited as these are in extent. Gear of various sorts should be used, but the most speedy for general purposes is probably the otter trawl, and if the development of fisheries is seriously considered the actual implement employed should be a net of something like the ordinary commercial size, preferably an actual commercial otter trawl. Good work can be done with a small otter trawl capable of working, as Dr. Hjort worked the trawl on the "Michael Sars," with bridles and a single warp, and this would be particularly useful in greater depths; but the spread is far less than that of a commercial net, and the power of capturing fish, especially those of large size, would be seriously diminished by substituting it for the latter. It is very desirable that, in some instances, at all events, a fine-meshed net should be laced over the cod end of the trawl, so that the small fish which would otherwise have escaped notice may be retained. In addition to this, fleets of drift nets, preferably with meshes of different sizes, should be used wherever there is any indication of pelagic fish moving in shoals, and possibly might be left anchored and buoyed throughout a short period. The same advantage of being able to leave gear for a short time is gained by the use of long lines, and these, in addition to hand lines, should certainly be employed. It might, for instance, be possible for the vessel to run round an island in a suitable depth leaving a trail or group of lines, and then repeat the circuit hauling in the lines laid.

One point is of the utmost importance in the success of such a survey, namely, that the gear should be worked by professional fishermen experienced in its use. It is necessary also that, when trawling, the actual handling of the ship should be dictated by the trawling master. If proper feeling is established between such men and the scientific leaders of the expedition, it should be possible to utilize this professional skill of the fishermen without limiting the operations to the precise methods and stereotyped procedure which the fishermen have been accustomed to follow in the execution of their calling. The naturalists' main fishery task would be to gather information as to the distribution, and particularly the density of the population, of each species at the sites investigated.

2.—Available Markets.

The nearest markets are those of South America. It is, therefore, of interest to note the approximate quantity and value of the fish imported into certain South American countries before the outbreak of war. The Argentine Republic is, owing to its position, perhaps the most promising for the marketing of fish from the Dependencies; and the following table summarizes the imports into this State, as given in the "Annuario de la Direccion general de Estadistica Argentina" for the year 1914.

Fish.	Chief Contributing Countries.*			Total.	
	Country.	Quantity.	Value in $1,000.	Quantity	Value in $1,000.
		Metric Tons.		Metric Tons.	
Fish, dry salted, mostly cod	Norway	3,629	517·0		
	Germany	309	45·0	4,635	660·0
	Netherlands ...	103	14·0		
	United Kingdom...	551	77·0		
Fish, wet salted	Spain	767	115·0		
	Italy	142	220·0		
	Netherlands ...	332	50·0	1,364	204·5
	Norway	4	0·7		
	United Kingdom...	12	2·0		
Sardines	Spain	1,681	420·0		
	Norway	567	142·0	2,629	657·0
	Portugal	175	44·0		
	United Kingdom...	28	0·7		
Fish, tinned	Italy	340	119.0		
	Spain	284	100·0	947	332·0
	United Kingdom...	139	49·0		
Total	...	9,063	1,915·4	9,575	1,853·5

* Sending more than 100 metric tons. Norway and United Kingdom stated in all cases.

In addition seventy-three metric tons of anchovies in brine were imported from Spain, Italy, and France, five metric tons of caviare from Russia and Germany, and three metric tons of anchovy paste, nearly all from the United Kingdom.

It will be seen that the quantity imported by Argentina was considerable, and, taking the dollar as equivalent to four shillings, the value was over £380,000. Moreover, while, as might be expected in a Roman Catholic country, salted fish predominates, tinned fish, sardines, and even luxuries such as caviare, find a market. The point, however, of the greatest immediate interest is the distant countries contributing to the supplies. Norway contributed seventy-eight per cent. of the staple articles, dry salted fish, while the wet salted fish and sardines were transported over distances almost as great.

Uruguay, a smaller country, naturally imported less, in 1915 taking in all six hundred metric tons, valued at $125,300, or about £26,000; like Argentina, it drew from Norway, the United Kingdom, the United States, and the countries of south-west Europe, and, like her, accepted not only salt fish, but small quantities of lobsters, sardines, etc. Chile, in 1913, imported 2,972 metric tons, valued at 1,630,000 pesos, or, approximately, £142,000. The European exports to the countries previously mentioned naturally are largely replaced by those of the United States in the imports of a country with a seaboard almost entirely on the Pacific. Almost exactly half of the total quantity imported by Chile consisted of salmon, ninety-three per cent. of which was from the United States, Great Britain sending sixty-six metric tons.

Brazil is the largest fish-importing State of South America, as is indicated by the following table of imports in the year 1913:—

Fish.	Chief Contributing Countries.*			Total.	
	Country.	Quantity.	Value (1,000 milreis).	Quantity.	Value (1,000 milreis)
		Metric Tons.		Metric Tons.	
Cod and similar fish ...	Newfoundland ...	25,842	11,804	49,569	25,210
	Norway	12,013	7,187		
	Canada	6,519	3,341		
	France	2,607	1,441		
Preserved and extracts ...	Portugal	2,306	2,501	3,892	4,250
	Italy	415	333		
	United Kingdom...	283	215		
Total	...	49,985	26,822	53,461	29,460

The table is not only of interest as showing the large quantity of fish imported into Brazil, but as clearly marking, for the period just before the War, the southern limit of the trade which could be said to be dominated by British North America. It may be confidently expected that Canadian and Newfoundland products will push more to the south in the near future.

The figures quoted are sufficient to show that the South American markets were able and willing to absorb large supplies of fish before the War. During the War the imports naturally declined. Thus, in the Argentine, imports of whole dry salted cod declined from 4,455 metric tons in 1914 to 1,872 metric tons in 1917—the mean price, in round figures, rising from 140 to 386 dollars per ton. This shortage of fish still continues, as is evident in several directions. In the Argentine, during the present year, both European and Japanese fish are fetching unusually high prices. The Chilean Government has found it necessary to deal with fish prices. Uruguay is again turning to the further development of her own fisheries; a fishery institute has been founded with the object of developing the industry in a scientific manner, and large refrigeration plants have been installed, which also act as a source of ice for public use. The probability is that in the existing meat shortage, which is generally expected to continue for some time, the importance of the fish element in the diet will be greatly increased The depletion of the great stock farms, and the enclosing of much of the land for smaller holdings or cultivation, works against a rapid recovery of the meat supplies, and

* Sending more than 100 metric tons.

even where these factors have not been at work to any great extent in South America, the greater demand which is current elsewhere would cause the shortage of meat to affect the situation. The near future is, therefore, not inauspicious for the introduction of new fish supplies. The distance of even South Georgia from South American ports is very considerable: from Buenos Aires it is distant approximately 1,560 miles, from Monte Video 1,500, from Rio Janeiro 1,875, from Punta Arenas 1,320. Port Stanley is, of course, nearer, and it must be admitted that the Falkland Islands clearly furnish the better base for a first step in developing fisheries industry, but the possibilities of the Dependencies as a further field of operations should certainly be explored.

3.—Commercial and Economic Considerations.

The actual fishing methods to be employed, assuming any workable fishing grounds to be discovered, will be determined by the research vessels, and it may be expected that for some little time direct and deliberate investigations into the best and most economical methods would be of great assistance. The same is true of the determination of the best means of placing the fish upon the markets. The fish at present imported from Norway, as will have been seen, is both dry and wet salted, but mainly the former; and under experienced managers, with competent scientific advisers, curing-houses might well be set up for salting, perhaps, also for smoking, at South Georgia. It is, however, necessary to bear in mind the fact that the supplies necessary for the preparation of the fish for the market would need to be imported. For wet salting, fishery salt and barrel staves would have to be brought; for dry salting, seeing it may be assumed that air drying could not be relied upon, coal would have to be used in addition, and even for smoking, wood or wood chips would have to be brought. Of these supplies coal presents the most serious difficulties, and would probably necessitate the highest order of expenditure. It is not at present found in the Dependencies, and, should the geological investigations result in its discovery, fisheries, like whaling, would benefit greatly.

It is important that before any actual marketing occurs an attractive product should be available. There should be no doubt as to the wholesome character of the fish, nor as to its palatability, as a mistake in either of these respects would have a very bad effect on the future of the trade. For this reason any products actually prepared for sale should, from the first, be under Government inspection before issue. Again, the actual market conditions should be studied, so that the consignments, especially the initial consignments, arrive at a suitable season. For instance, the increased consumption during Lent may be borne in mind. Poultry and eggs are abundant in the southern countries of the continent, and at certain seasons are very much used. A consignment of fish would have the best chance of a satisfactory test if it arrived during Lent or at some season when alternative foods are least varied or least abundant.

It is not improbable, however, that the best chance for the Antarctic fisheries in the South American markets would lie in their presenting a more acceptable article at a reasonable cost, and of this the lesser distance to be travelled and the climate give some hopes of accomplishment. Unsalted fish could be delivered either canned or frozen. Canned fish presents the best chances, having the advantages of storage and transport inland without deterioration, and being, moreover, a commodity already in use. Canning, it is true, has the disadvantage that tin-plate would have to be taken long distances to the site of operations, but developments which are taking place in the methods of refrigeration, particularly by brine freezing, give good hopes that this method might also be used. There would be no doubt of getting the fish in good condition to South Georgia, or to the Falkland Islands; and, if the trade developed, there should be no difficulty in getting it to the ports of the La Plata, at all events, with practically all the advantages of freshly caught fish.

In considering the possibilities of a fishery arising in the Dependencies, it may be well to mention in a collected form certain disadvantages under which an industry based on South Georgia would labour. The need for importing fishery supplies has already been mentioned, and in this connexion the export of frozen fish, it should be noted, has the advantage that necessary supplies would be less in amount than for the preservation of fish by other methods. Salt, tin-plate, wood for boxes, barrel staves, hoops, and for smoking, and particularly coal, would all

need to be taken to the islands for one or other of the processes which would probably be carried out. Coal is the most serious factor, since it would not only be used in the preparation of the fish, but probably in considerable quantity in the running of the fishing vessels, although it is only fair to add that the use of oil-driven vessels would largely mitigate the difficulty connected with fuel. The import of these commodities would entail considerable development of the existing transport, which is almost entirely taken up with the import of coal and other supplies for the whalers, and the return freight of oil, and while the fact of this trade existing as a nucleus makes the difficulty less than the initiation of an entirely new traffic would involve, there is no outward cargo space available, the remoteness of the islands from the general trade routes, with the resulting absence of occasional opportunities for utilizing spare cargo space, would certainly lessen the advantages which accrue from the shorter distance in transport as compared with the traffic at present carried out between the South American States and the countries which furnish them with fish. Whether it would actually cancel these advantages is, however, very doubtful, and in all probability can only be ascertained by experience.

A great difficulty of another sort is that it might not prove easy to man the fishery by British labour. The experience of the whaling industry might be duplicated and a trade develop which was staffed by alien labour, with different standards of comfort and living. A partial remedy might be found in a very careful regulation of the accommodation in all vessels licensed to fish, together with a fostering of a profit-sharing basis for the work carried out.

Summing up, while admittedly the prospects for fisheries in the Dependencies appear to be inferior to those for the Falkland Islands, there seems to be quite a possibility of an industry of some value arising, and the steps which appear to be necessary are:—

(1) Intelligent survey of the grounds, the sites chosen for investigation being selected not only on the basis of previous records of fish taken, but in reference to the physical characters of the ground and water.

(2) Investigation of the suitability of the species found for food, and of the best methods for their preservation, not only by salting, but still more by canning and freezing.

(3) Careful determination of the best methods of fishing and proper care for the welfare of the men who should carry out the trade.

(4) A definite and well thought out policy in launching the products on the South American markets.

(5) In the event of a commercial fishery actually being established in the Dependencies, its preservation will become a matter of importance, and with this end in view complete statistics of capture and of export should be collected from the first.

It must be fully admitted that to carry out the recommendations made or implied in this memorandum would involve not only a large amount of work and forethought, but considerable expenditure. If, however, the economic possibilities of fisheries in the Dependencies are to be explored, nothing less than a thorough investigation would avoid misleading conclusions or the risk of failing to recognize the presence of real assets.

J. O. BORLEY.

June, 1919.

APPENDIX XVIII.

FAUNA OF THE DEPENDENCIES OF THE FALKLAND ISLANDS.

1.—Indigenous Life.

(*a*) *South Georgia.*—One or two species of hair seals, especially the sea-elephant, are common, but the fur seal, which at one time was numerous, appears to have been exterminated about forty years ago. A single specimen, probably a casual visitor, was found and unfortunately killed by mistake early in 1915; no further specimen of the fur seal has been observed in South Georgia since that year, and the possibility of re-establishing the species in its old haunts is under consideration. The seals of South Georgia and the other Dependencies are dealt with in a separate memorandum.*

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* Appendix XIV.

Commander Hodges, H.M.S. "Sappho," who visited the island in 1906, stated that traces of some species of otter had been reported, but that, with this exception, there were no land animals indigenous to the country. There were many kinds of sea birds, including albatross, penguin, cormorant, Cape pigeon, "Cape dove," small terns, etc. Of land birds there were two species—larks and the *Chionis* or sheathbill. It has been stated that there are a lot of duck, although none were observed on that occasion.

The Magistrate reported in 1910 that land birds were very few, the only one he had seen being a kind of lark. He had heard of the existence of some fresh water duck, apparently resembling a teal.

In an article entitled "The Desolate Island of the Antarctic," which was published in the *American Museum Journal* for October, 1913, Mr. R. C. Murphy mentions that twenty-three species of birds breed in South Georgia. The native gulls, terns, tit-larks, ducks, and the larger Tubinares nest upon the ground, trusting the safety of their eggs to protective colours, concealment, or constant guard; but the lesser petrels nest in deep burrows, in order to escape the predatory skua gull. Extraordinarily populous among the many inhabitants of the tussac hillocks he found the petrel *Procellaris æquinoctialis*—the "black night hawk" of our (i.e., American) sailors, and the "shoe-maker" of the Norwegians.

In a report dated 14th May, 1914, the Magistrate stated that the gentoo penguin (*Pygoscelis papua*) nests in millions round the island, being the best known penguin there is, and showing itself everywhere and at all times; but that it is very questionable if the *Aptenodytes* or king penguins have ever been very numerous at South Georgia. Captain Rasmussen informed the Magistrate that he had never seen very large rookeries of this species, although he was certain there must be thousands round the island; and he lately observed the following rookeries, the numbers given being, of course, very approximate:—Sandwich Bay, about 600 king penguins; Royal Bay, about 500; St. Andrew's Bay, about 300; Antarctic Bay, about 100; Right Whale Bay, about 400; also a number at North Bay (south-west coast) and a number in Bay of Isles (this season), over 200 young.

Captain Rasmussen had seen gentoo penguins in great numbers everywhere, and had observed during the nesting season millions of rock-hopper penguins on Wallis Island, also great numbers on Bird Island, Welcome Island, and Else Bay. The Magistrate said he could be almost positive there was practically no killing by human agency with the exception of those permits—at most very few—granted for food and scientific purposes. He points out that penguin eggs in South Georgia form a very rare and important article of food on an otherwise bare and desolate island, and that they are not so easily obtainable as might be thought. He was unable to admit any decrease in the number of penguins, and suggested that if he emphatically declared that "at the present time there are millions of gentoo and rock penguins, and thousands of king penguins (whose eggs are very seldom taken) round South Georgia, even with the egging that had taken place within the past five years," it should be enough to calm the fears of the suspicious naturalist who sights in the egging trips a prelude to extermination. In the same report the Magistrate asserts that the local protecting laws (*vide infra*) are respected by the usual inhabitants of the Dependency.

(*b*) *Other Dependencies.*—Information as to the seal life in the remaining Dependencies will be found in the memorandum on the Sealing Industry.* The introduction of fresh fauna (other than the reintroduction of the fur seal) with a view to their acclimatization, is scarcely an economic proposition, having regard to the fact that these Dependencies are ice bound and in general uninhabited for the greater part of the year. The following notes extracted from official and other records may, however, be of some interest.

(1) *South Shetlands.*—In notes on his visit to the South Shetlands during the whaling season 1916-17 the Magistrate observed thousands of Cape pigeons on Deception Island, and discovered an egg of a stormy petrel, which breeds almost everywhere along the fringes of the Antarctic regions. He also came across isolated nests of the southern black-backed or dominican gull, and observed large numbers of sheathbills or paddies (*Chionis alba*), known in the Falkland Islands as the kelp pigeon. According to the *South America Pilot* sea fowl, such as albatrosses and penguins, are numerous in the South Shetlands. A list of species represented in a collection sent to the British Museum in 1914 will be found in Annexure II.

* Appendix XIV.

(2) *South Orkneys.*—In the "Voyage of the Scotia" mention is made of the presence of various varieties of penguins, and of many kinds of birds, including the albatross, giant petrels, shags, Cape pigeons, snowy and stormy petrels, sheathbills, etc.

(3) *South Sandwich.*—In the report by Captain Larsen on his exploring expedition to the Sandwich Islands in 1908, he reports that thousands of the small snowy petrels (*Pagodroma nivea*) and Cape pigeons (*Daption capensis*) were seen nesting on Lieskov. On Zavodovski he observed thousands of penguins of three different kinds, the most numerous being those that have a fine yellow crest over both eyes, probably *Eudyptes chrysolophus*; as well as thousands of Cape pigeons observed nesting on Visokoi. Numerous rookeries of penguins were seen on Candlemas; they were of two species, the black-chinned and that with the black stripe underneath the chin.

2.—Imported Life (South Georgia).

In connexion with experiments in acclimatization the following description by the botanist of the Swedish Antarctic Expedition (1902) of the physical features and plant life in South Georgia may be of interest:—

South Georgia is an alp-land, rising very steeply out of the sea with innumerable mountains. Immense masses of ice and snow occupy the interior parts, and large glaciers open out into the fjords. The lowland takes up very inconsiderable areas round the coast, and it is divided by high ridges into small valleys. The vegetation in the valleys is rather luxuriant, though composed only of some few phanerogamic plants; the tussac grass covers the sandy seashores and goes into the valleys and up the slopes. Where the tussac grass does not grow we find either meadows or bogs. The meadows are composed of some few grasses, mostly *Festuca erecta*, very short and stiff, and certainly not so good for pasture as the grass on the Falkland Islands. The bogs occupy considerable areas; the plants growing on them are very small and less valuable.

Specimens of grasses, etc., were collected during the visit of H.M.S. "Sappho," and a list of determinations furnished by the Director, Royal Botanic Gardens, Kew, will be found in Annexure I. to this memorandum.

Rats, probably imported from vessels, are found in South Georgia, and experiments have been made in introducing sheep, rabbits, reindeer, horses, and geese.

Sheep.—The expedition of the South Georgia Exploration Company, which visited the island in 1905, landed some ewes which lambed successfully. The manager stated that he had experienced weather much more trying to stock in Patagonia and Tierra del Fuego than he met in South Georgia. The island was, however, regarded as useless for sheep-farming, although in places the grass is sufficient to keep flocks of from 200 to 500 sheep for consumption locally if required. The main difficulty is that the area of suitable land near the coast is extremely limited, and inland it is mountainous and ice-bound. The expedition on its departure in November, 1905, left behind the ewes with lambs, seventeen in all. The Officer Commanding the "Sappho" reported in February, 1906, that these animals had taken to the slope of the hills, but were not expected to survive if left to the severity of the winter; and apparently they all perished.

The botanist of the Swedish Antarctic Expedition, 1902, regarded sheep-farming as an impossibility. He considered that only one of the numerous exceedingly strong storms would kill the whole stock of sheep.

It may be noted here that, in a report made in 1917 by the Magistrate, he states that before sheep were placed on Mutton Island in Stromness Bay, this island was covered with tussac, but that it is now bare and nothing remains except the withered roots. Moraine Flat, near the whaling station of Grytviken, is stated in the same report to be the most suitable place for grazing. It could, perhaps, support about 1,000 sheep, but in the summer months only, as sheep very rarely survive the winter unless housed and hand fed. The view is expressed that goats would have a much better chance of existing throughout the year, though it is suggested that the "Bighorn" of British Columbia might survive.

Brown Rat.—This animal appears to have been introduced about 1800, and has become firmly established along the whole northern coast at least. During the hundred years of its life in South Georgia it has varied enough to be given a

sub-specific name (by Lönnberg in 1906). It eats tussac grass, but has become largely carnivorous, preying upon the burrowing Tubinares (petrels, etc.).

Rabbits were introduced about 1872, but did not survive. The Officer in Command of H.M.S. "Sappho" reported that some rabbits had been brought from Buenos Aires and appeared to be thriving. On the other hand, the Magistrate stated in 1910 that rabbits had recently been brought to the island, but, in one instance, with little success, owing to the hawk-like ferocity of the "sea-hen."

Reindeer.—The first importation, consisting of three bucks and seven does, was made in 1911. The animals were brought from Numedal in the central part of Norway. According to a report dated 1917, there were, when last observed, forty-five animals in one herd, and it is believed that there are other small herds.

A second importation of two bucks and five does was made in March, 1912. The animals were liberated at Leith Harbour, and two months after their arrival three calves were born, but only one survived the winter. They have since increased in numbers, and, when last reported, in August, 1917, one herd consisted of seventeen animals. In a recent despatch the Governor states that he considers it would be advantageous to introduce fresh blood, but that South Georgia does not appear suitable to carry any large herds on account of the difficulties of feeding, especially during the winter months.

Horses.—Three mares and one stud horse were introduced into the island by the South Georgia Exploration Company in 1905. They are stated to have thriven in a completely wild state, but are confined to a limited district in Cumberland Bay, since they cannot cross the glaciers.

Geese.—Early in 1910 the Magistrate reported that he was endeavouring to secure the introduction of some Upland, Brent and Kelp geese from the Falkland Islands in the following spring. It is stated that an experiment in this direction was made and that the geese throve.

3.—Protection Laws.

(*a*) *General.*—In 1912 an Ordinance was passed providing for the preservation of certain wild mammals and birds in South Georgia. The Ordinance prohibited the killing or the taking of the reindeer or the Upland goose, and provided a close season in respect of the following birds: duck, teal, widgeon, and giant petrel.

This Ordinance was, however, considered to be defective in several respects. It was, therefore, repealed by Ordinance No. 1 of 1913, which applied to both the Colony of the Falkland Islands and its Dependencies, and (*a*) prohibited the killing, wounding, or taking at any time of wild mammals or birds included in Schedule I.; (*b*) provided a close season (October to February, both months included) in respect of wild mammals or birds included in Schedule II.

The schedules to the Ordinance were as follow:—

Schedule I.

Reindeer.
Kelp goose (*Bernicla antarctica*).
Thrush (*Turdus falklandicus*).
Wren (*Troglodytes cobbi*).
Scoresby's gull (*Larus scoresbyi*).
Kelp pigeon (*Chionis alba*).
Red-breasted starling (*Trupialis falklandicus*).
Cinclodes (*Cinclodes antarcticus*).

Schedule II.

Blacknecked swan.
Widgeon.
Grey duck.
Teal.
Giant petrel.
Double-ringed plover (*Ægialitis falklandicus*).

White or coscoroba swan.
Pintail duck.
Mallard (*Anas boschas*).
Grebe.
Snipe.
King-shag (*Phalacrocorax atriceps*).

In addition the Ordinance provided for the granting of licences to take the mammals or birds mentioned in the schedules, and gave power to vary the close season. The issue of licences in the Dependencies was left to the discretion of the Stipendiary Magistrate, in view of the difficulty of communication, and the fact that applications for such licences for other than scientific purposes would be comparatively rare.

Subsequently penguins were added to Schedule I. of the Ordinance, and the grebe was transferred from Schedule II. to Schedule I. The Governor advised against including the Upland goose or the Brent goose in Schedule II., since such a step would cause much dissatisfaction throughout the Falkland Islands, where these birds are regarded as a nuisance.

Reindeer have been introduced into South Georgia, but, as Ordinance I. of 1913 also applies to the Falkland Islands, it is not to be assumed that all the birds mentioned in the schedules are to be found in the Dependency, e.g., the species of thrush, wren, starling, and *Cinclodes* mentioned in Schedule I. were understood to be peculiar to the Falkland Islands.

(*b*) *Penguins.*—Ordinances were passed in the years 1864 and 1866 making it a penal offence to kill penguins in the East Falkland and certain adjacent islands. These Ordinances were repealed by Ordinance I. of 1867, which empowered the Governor to grant licences to kill penguins and imposed penalties for killing without a licence. At one time there was a considerable industry in the boiling down of penguins for their oil, but it has not been carried on now in this district for many years.

The first Ordinance for the protection of penguins in the Dependencies was passed in 1909, and made it unlawful to take these birds without a licence.

The Ordinances of 1867 and 1909 were repealed by Ordinance No. 9 of 1914, which prohibited the taking of penguins without a licence in specified portions of the Falkland Islands or in the Dependencies. In view of the repeal of the 1867 Ordinance the effect of the Ordinance passed in 1914 was to afford protection to the eggs only of the penguins and not to the penguins themselves; and, in consequence, by a Proclamation, dated the 14th December, 1914, all species of penguins found in the territorial waters of the Colony and its Dependencies were added to Schedule I. of the Wild Animals and Birds Protection Ordinance, 1913 (*vide supra*).

H. T. ALLEN.

16th October, 1918.

ANNEXURE I.

Plants collected in South Georgia during a visit of H.M.S. "Sappho." Communicated by the Colonial Office, 5th April, 1906.

The plants are:—

Ranunculus biternatus, Sm.
Montia fontana, L.
Crantzia, sp., very similar to *C. lineata*, Nutt., from the Falkland Islands.
Acaena adscendens, Vahl.
Acaena sp., probably the same which Engler determined erroneously as *A. laevigata*, from South Georgia.
Phleum alpinum. L.
Poa flabellata, Hook. f.
Festuca erecta, Urv.
Barbula runcinata, C. Müll.
Hypnum austro-stramineum, C. Müll.

Crantzia was not known previously from South Georgia. It is an interesting addition to the scanty phanerogamous vegetation of the island.

Royal Botanic Gardens, Kew,
10th April, 1906.

ANNEXURE II.

List of species represented in a collection sent to the British Museum from the South Shetlands.

Macaroni penguin (*Eudyptes chrysolophus*).
Ringed penguin (*Pygoscelis antarctica*).
Adélie penguin (*Pygoscelis adeliae*).
Wilson's stormy petrel (*Oceanites oceanicus*).
Giant petrel (*Ossifraga gigantea*).
Cape pigeon (*Daption capensis*).
White-rumped tern (*Sterna hirundinacea*).

APPENDIX XIX.

MEMORANDUM ON THE HYDROGRAPHY OF THE DEPENDENCIES OF THE FALKLAND ISLANDS.

1.—GENERAL HYDROGRAPHY.

IN discussing the general hydrography of the various areas the greatest difficulty arises on account of the exceeding meagreness of the information that we have. The only portions that can be said to have been in any sense surveyed are the south-western portion of Graham Land, which was examined by Dr. Charcot, and small portions of Deception and King George Islands in the South Shetlands, but even these call for considerable further examination.

(1) *South Georgia.*—This island itself, as charted, is dependent upon various old reports, a very incomplete and sketchy survey by the German expedition of 1882 and a number of plans by various whaling captains, which, though of some value, are also exceedingly incomplete, and difficult to connect. The harbours on the south-west coast, and several of those on the north-east coast, appear never to have been examined at all, and none have been examined in sufficient detail. In 1912 Mr. Salvesen, in a letter to the Colonial Secretary of the Falkland Islands, pressed very strongly for a survey at least of the north-east coast, which he considered could be carried out by an officer with one or two assistants using local aids. This appears to me to be quite feasible, provided a whaler-built motor-boat could be furnished, so that the party would not be entirely dependent upon the whaling community. This would relieve the research ship for work which, thougl possibly of less importance, could not be carried out without her.

Within the area of South Georgia may be included the Shag Rocks, to the westward, and a rock reported in 1916 to lie in latitude 58° 31′ S., longitude 41° 48′ W., the positions of which are exceedingly doubtful. Lying as they do immediately in the whaling area, it is a matter of importance that as soon as possible their positions should be verified and their neighbourhood examined by the research ship.

(2) *South Sandwich Islands.*—These islands are very poorly charted, the little information we have on them being from Bellingshausen (1820), with a few remarks from Larsen. The remarks of the latter are not very encouraging, but, lying so far to leeward as the islands do, it is very desirable that they should be examined and fixed, with a view to the discovery of possible harbours or sheltered anchorages which would be useful to vessels working in, or driven into, their neighbourhood.

There appears to be no doubt that there is a good harbour at Southern Thule, but in normal years it is probably unapproachable on account of ice.

A harbour has also been reported at Bristol Island, but nothing definite seems to be known about it.

Should no accessible harbour be found, the delay caused by the examination of the group would be short, whereas, if any were found, the results would be very valuable.

(3) *South Orkneys.*—The existing chart of this group is very poor. Some work has been done here by the "Scotia," but it only appears to prove that a great deal more is required. Harbours undoubtedly exist which require more thorough surveying than has yet been done, and no attempt appears to have been made to connect the various islands by triangulation. The Argentine meteorological station on Laurie Island might doubtless be able to assist here, if only in housing a party of surveyors.

In addition to a complete examination of this group, a thorough examination of the sea to the westward as far as Clarence Island is very necessary. A reference to the chart shows that no soundings have ever been obtained here, and rocks and dangers very probably exist.

(4) *South Shetlands.*—Here, again, the information we have is very incomplete and disconnected, while it is known that there are many harbours and anchorages which require examination and are not shown on the existing chart. Dr. Bruce's chart, when produced, will be a very great improvement on the present one, but, being only a compilation from a great mass of very disjointed material, cannot pretend to great accuracy, and a complete survey of the group is very necessary. It is probable that the only permanent portion of his chart will be the nomenclature, which was in a very confused condition before he undertook the work, and to which he has devoted a great deal of time and research.

(5) *Graham Land.*—The south-western portion of Graham Land, examined by Dr. Charcot, is probably the best surveyed part of the Dependencies, but the northern end, from the whaling point of view the most important portion, is little better than the others. There are undoubtedly many useful harbours in this area, and a thorough examination of it will occupy a considerable period.

(6) *Weddell Sea.*—Of the shores of this sea extremely little is known, and it is probable that very little could be done here by the research ship. Should, however, a favourable opportunity occur it would be useful to verify or disprove Ross's "strong appearance of land," about which there has been so much controversy among Antarctic geographers.

2.—Tides and Tidal Streams.

There have been very few tidal observations throughout the Dependencies, but it is known that the range is small. As the Dependencies are in the area from which the great tidal wave starts, systematic observations are, however, very desirable. Consequently it would be a great advantage if an automatic gauge could be established at South Georgia, where the record could be maintained throughout the year. Possibly also the Argentine meteorologists might take charge of one in the South Orkneys. Elsewhere an ordinary gauge would have to be used, night and day observations being still obtained, but necessarily for short periods only.

Observations on tidal streams are very much wanted, and would be obtained in each case as the various surveys progress.

3.—Ice

No connected or systematic observations on ice in these areas appear to have been made, and it is very desirable, from a hydrographical, meteorological, and whaling point of view, that some should be made.

4.—Deep-Sea Soundings.

The number of deep-sea soundings within the various areas are exceedingly few, excepting in Weddell Sea, where, however, there are still many gaps. It seems desirable that every opportunity should be taken to obtain these soundings, particularly in the quadrilateral roughly limited by Cape Horn, South Georgia, South Sandwich Islands, and the South Shetlands. Probably this could be done in conjunction with trawling and a study of the chemical conditions of the sea water, which appear to be desirable.

5.—Summary.

The above remarks show that a very large amount of work is required to make complete surveys of the various groups, work which would probably take several years, as the working season would seldom, if ever, exceed five months, excepting possibly in South Georgia, where it might be a little longer.

The period occupied would, of course, largely depend upon the size of the vessel and the corresponding staff. If so small a vessel as the "Scotia," about 300 tons, with a correspondingly small staff, were used, the work would be very slow; but, if Dr. Bruce's suggestion of a vessel of 1,200 to 1,500 tons, with a staff of five or six surveying officers in addition to the scientific staff, were acted upon, parties could be left to survey harbours and do other inshore work while the ship was on the more exposed work and engaged on other scientific matters, and consequently the work would progress very much more rapidly.

CHAS. V. SMITH,
Captain, R.N.

Admiralty,
24th June, 1918.

APPENDIX XX.

(*a*) MEMORANDUM BY AND (*b*) NOTE OF INTERVIEW WITH DR. G. HERBERT FOWLER, HYDROGRAPHIC DEPARTMENT, ADMIRALTY.

(*a*) MEMORANDUM.

I UNDERSTAND that I am to express to the Committee my views as to the importance of adequate oceanographic investigation of the area under consideration, before complete regulation of the fisheries is attempted. While our knowledge of Antarctic oceanography is still very small, it will not be difficult to show how vitally significant such investigation may prove to be. In discussing this matter it is fair to argue to some extent from observed facts in the Arctic area, because most of the Arctic conditions of life are repeated in the Antarctic.

As an example of the probable importance of oceanographic research, I propose to take the problem of the migrations of those three whales mainly hunted in the southern ocean, all of which are primarily plankton feeders, though they may also take small fish. Now the basis of the whale-food in the open ocean, not only as direct food but also as food for other constituent organisms in whale-food, is to be found in the oceanic diatoms in both polar regions. By analogy from the Arctic evidence we may say that these flourish luxuriantly only in cool waters of rather low salinity, that they are reduced in numbers almost to zero in winter, begin to flourish in spring, attain a maximum in summer and early autumn, to die down again presently.

The distribution of a marine animal is conditioned generally by food and temperature—perhaps, one might say, by the temperature at which its food best flourishes; at any rate the latter statement would seem to be true of whales, which the layer of non-conducting blubber seems to make almost independent of water-climate. The study, therefore, of the temperature, and the comparative abundance of diatoms and other plankton in the surrounding seas through which whales might perhaps migrate, ought to bring out the only routes along which they can possibly migrate.

There is already a certain amount of evidence—of a very general nature—to show in what seas diatoms may be expected to be found in abundance during the Antarctic winter, when they may be supposed to be in abeyance in the extreme south. Consideration of the chart (*produced*) will show that, so far as mean isotherms and current observations may be taken as a guide, the circumpolar Antarctic drift sends branches (*a*) up the western side of South America, with cool water nearly to the tropics; (*b*) up the eastern side of the same continent only about as far as 45° S., where it is checked by warm water pressing southward from the tropics; (*c*) up the west coast of Africa as far as 15°-20° S. (not up the east coast); (*d*) up the west coast of Australia (not up the east coast); (*e*) along both eastern and western shores of New Zealand.

In these waters we ought to find the oceanographic conditions suitable for an abundant diatom flora and ample whale food, and we ought to find also that migrant whales from the Antarctic do not extend northwards of a particular isotherm—the optimum temperature for the development of their food. Other factors may be expected to increase the supply of whale-food in some of these cool branches of the Antarctic drift: the upwelling of cool water from below along the west sides of the continents, which compensates for the surface water drawn off by the trade winds, brings an abundant fauna to or near to the surface; the presence of neritic or coast-living diatoms, as well as the solid organic matter brought down by rivers, notably on the West African coast, will be further contribuents to the food supply.

On the other hand, in the middle of the warmer oceans the fauna, which corresponds to the surface plankton of cooler seas, is probably not so abundant, and certainly lives at a deeper level. Consequently one would expect to find that the routes of whale migration did not pass through the cyclonically-moving waters of the middle South Atlantic and South Pacific oceans.

These hypothetical suggestions as to migration may, or may not, correspond with fact, but will serve to show at least one of the lines along which oceanographic research would be not only useful, but necessary, to a comprehension of whaling problems. The same research would be needed for regulation of

sea fisheries if their development is contemplated. But, so far as I am aware, no observations on the comparative volumetric abundance of diatoms and other plankton in these waters at different seasons have been recorded; while observations on the drifts, tides, temperatures, and salinities are few and scattered, both in space and time. The outlines of our knowledge are of the sketchiest character.

The work needed from the oceanographic point of view would comprise the study of (1) the fauna and flora, including contents of stomachs; (2) the temperature and salinity of the water, from which the density can be calculated at any time; in some places chemical analysis of the water might also be desirable; (3) drifts, currents, and tides; all these three should be observed, both at the surface and at certain prearranged depths. I have read Mr. Rudmose Brown's memorandum, dated 3rd February, 1917*, and Mr. Fagan's letter, of 31st December, 1917* and concur generally with the suggestions as to the scientific staff, except in that I feel very strongly that the "Surveyor" should be, not a scientific man in the ordinary sense, but a properly trained officer of the Surveying Service of the Royal Navy, who should be the master of the vessel. We have suffered sufficiently in some previous Antarctic expeditions from commanding officers who had no comprehension of, or sympathy with, scientific work; and accuracy in surveying—which is not merely valueless but dangerous if inaccurate—can only be got by a long course of training which scientific men have neither time nor opportunity to acquire. Surveying is, of course, essentially "scientific" in its methods, and in my experience officers of the Surveying Service, although not trained in oceanography, have necessarily a general understanding of its principles and appreciation of its usefulness.

G. HERBERT FOWLER.

Admiralty,
2nd July, 1918.

(*b*) Note of Interview with Dr. G. Herbert Fowler.

Dr. Fowler read his memorandum, and in the course of the discussion elaborated the following matters connected with the work required from the oceanographic point of view:—

1.—Plankton.

It will be necessary to pay considerable attention to the more important aspects of this question, if it is desired to obtain information as to the connexion between the movements and abundance of plankton and the migration of whales, and, indeed, if a knowledge of the causes of these migrations, such as is essential to the proper understanding of the problems they present, is to be obtained. Much valuable evidence would no doubt be furnished by the mere volumetric estimation of the plankton, even if confined to ascertaining the total food-content of the water and not extended to a detailed investigation of the identity and distribution of all the species of plankton met with. On the other hand, it would be necessary to investigate from time to time the quantity and distribution of selected species known to be important constituents of planktonic whale-feed, which is clearly abundant in the Antarctic, and must to some extent be carried to the north.

Dr. Fowler did not consider it established that plankton in the first hundred fathoms of the warmer waters of the Atlantic (although presumably not whale-food) is less in total volume than in the waters of the Frigid Zone, and there is no evidence where the change of character of the plankton occurs.

Dr. Fowler was of opinion that valuable results could be obtained from (say) a three years' study of the fauna and flora; and he contemplated that the investigation would be limited to floating life and not be extended to life on the bed of the ocean.

2.—Salinity and Temperature.

The salinity of the water, while perhaps not directly affecting the migration of whales, may not improbably have an important bearing on the distribution of the

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* Not printed.

plankton, and in this connexion the desirability of occasional chemical analyses was emphasized. The study of salinity is important also as affecting the density of the water and thus bearing on the power of diatoms, resting spores, etc., to float.

Further observations of the temperature of the water, which is certain to affect plankton abundance, are needed in view of the considerable variations that are known to occur, and it would be necessary to take these and salinities at several depths.

3.—Currents.

Dr. Fowler produced a chart illustrative of the currents of the oceans of the world, and also a further chart which he had specially constructed for the Committee, showing the movements of the circumpolar Antarctic drift with its branches. These are mentioned in his memorandum, and fully described in Captain Smith's memorandum* on the currents of the South Atlantic, which are also before the Committee.

Generally speaking, there is an easterly drift through the Dependencies of the Falkland Islands, and Captain Smith explained that the observations of this drift had been based on the ascertained difference between the dead reckoning positions and the observed positions of vessels. There are, however, comparatively few observations on record south of the fortieth parallel of latitude, except in the neighbourhood of Cape Horn; and further observations are much needed.

As regards observations of drift tides and currents, Dr. Fowler pointed out that within limits floats were useful for ascertaining direction, but of little value for estimating velocity, the indications being inconclusive except for floats recovered very soon after they had been put out. Experiments with floats around the British Isles had not yielded results satisfactory in all respects, except over very short periods, and the difficulties there experienced would be largely increased in the little-frequented waters of the Antarctic.

4.—Area of the Investigation.

Dr. Fowler said that he had not given consideration to the question of the area over which the investigation should be made, but *prima facie* it should at least cover the waters through which the whales are thought to migrate.

5.—General.

The main trend of Dr. Fowler's evidence was to the effect that the biological and chemical researches he had mentioned were essential to the collection of such data as alone would enable a rational and soundly based consideration to be given to the problems other than economic with which the Committee must be prepared to meet.

9th July, 1918.

APPENDIX XXI.

MEMORANDUM ON THE CURRENTS OF THE SOUTH ATLANTIC OCEAN

1.—General Circulation.

The currents of the South Atlantic, while necessarily affected by local winds and conditions, are greatly dominated by the general easterly drift which sweeps round the globe approximately between the thirty-fifth parallel of south latitude and the ice barrier.

This great mass of water, travelling at a rate sometimes as great as thirty miles per day, with a width of one thousand eight hundred miles, through one hundred degrees of longitude, is suddenly reduced between Cape Horn and the South Shetlands to a width of five hundred miles. While a portion of it runs up the

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* Appendix XXI.

west coast of South America forming a cold current, the bulk of it passes through this comparatively narrow passage south of Cape Horn at a rate attaining frequently as much as fifty miles per day.

After passing Cape Horn the current fans out considerably and flows generally to the eastward and north-eastward towards the Cape of Good Hope, at a very much reduced rate.

On reaching the Agulhas bank southward of the Cape of Good Hope, the northerly portion of this current is deflected to the northward along the west coast of Africa, and, by the trade winds, to the north-westward. The former attains a rate of forty miles, and even sometimes fifty miles, per day, but the trade drift in its southern portion is considerably weaker.

The West African current on or about the equator joins the Guinea current which sets easterly along the south coast of Guinea, and with the trade drift they sweep to the westward, forming the equatorial current, having a speed which frequently attains fifty miles per day.

This last great current, on reaching approximately the thirtieth meridian, divides, the bulk of it running along the north coast of South America, but a considerable portion running down the east coast, where it also frequently attains a speed of fifty miles per day. On reaching the Rio de la Plata the greater part of this stream turns to the eastward and is merged in the general easterly drift, but a portion of the Brazil current can be traced as far south as Magellan Strait as a distinctly warm stream.

2.—Periodical Variations.

The periodical variations in the currents of the South Atlantic are not of great consequence. The most important is the change in the northern limit of the great easterly set, which, in mid-Atlantic, say longitude 15° W., is in about latitude 30° in January and latitude 25° in August.

The trade drift during the summer months is generally rather greater than in the winter ones, due to the stronger trades blowing at that time.

3.—Surface Temperatures.

The surface temperatures of the South Atlantic are well shown for four standard months on Admiralty chart No. 2930, a copy of which is attached.

The most marked features of these are :—

(1) The area of comparatively cold water running up the west coast of Africa, which, though the actual temperature is then higher, is most marked in the summer months.

(2) The very variable temperatures that occur near the northern limit of the easterly drift, particularly in the summer months. This is probably due to a certain overlapping of the easterly drift, which is cold, and the trade drift, which is comparatively warm, as well as to a mingling of the Brazil current, a decidedly warm one.

(3) The great difference in temperature of the water on the two sides of the ocean, which, however, is most marked in the winter.

CHARLES V. SMITH,
Captain, R.N.

Admiralty,
4th July, 1918.

APPENDIX XXII.

MEMORANDUM OF INTERVIEW WITH SIR NAPIER SHAW, LL.D., Sc.D., F.R.S., DIRECTOR OF THE METEOROLOGICAL OFFICE.

1.—General.

Starting from the assumption, apparently put forward by Dr. Bruce for Mr. Mossman, that the area embracing the Dependencies of the Falkland Islands furnishes, in a special measure, the key to some of the problems of meteorology, Sir Napier Shaw explained that, from the meteorological point of view, it is not possible at the present time to say that, by fixing upon one locality and organising observations there, corresponding observations at other localities, specified or

unspecified, can be dispensed with. The use of the expression *centres of action* is liable to convey much more than is really meant to those who are unfamiliar with the progress of meteorological inquiry. It does not mean that the "centres of action" which have already been recognised together represent the sum total of the controlling agencies of the atmosphere: there may be others in regions unexplored in the geographical or meteorological sense; nor does it mean that action in the sense of influence upon the general circulation of the atmosphere is confined to any system of centres of action to the exclusion of all the rest of the globe.

Such ideas may form the basis of a reasonable working hypothesis for the general phenomena of terrestrial magnetism, in which we can recognise "magnetic poles"; lines drawn on the globe represent the actual state of the earth as regards magnetism, which changes very slowly, and is only occasionally disturbed by magnetic storms, but, in meteorology, the general state of the atmosphere which we contemplate is a general *circulation* consisting of a system of currents of wind which has some general characteristics but is constantly changing in detail in every part of the globe, and in which disturbances corresponding with the magnetic storms in the magnetic case are constantly developed and are an essential part of the system. The only way of arriving at a satisfactory view of that circulation is to obtain a complete survey of the meteorological conditions of the globe by observations in every part of it. Until we get a complete survey the inferences drawn from a partial survey are not conclusive.

At present, in spite of the co-operation of all countries, we have only an imperfect survey. It is represented in its most advanced form by the *Réseau Mondial*, published by the Meteorological Office as a contribution to this important enterprise. This publication forms one of the parts of the British Meteorological and Magnetic Year Book, and contains summaries of pressure, temperature, and precipitation at land stations, generally two for each ten-degree square of latitude and longitude, although the number for many areas falls short of this standard. It may be noticed with regard to the survey that it is especially inadequate in the polar regions; and in that connexion it should be remarked that the polar regions, as forming the supply of cold surface air for the general circulation, are at least as important, and probably more important, than any equal area in other parts of the world, so that regular information from polar regions is of exceptional value.

The process of obtaining a sufficient survey is for each centre of organised human habitation to keep a proper meteorological record, not only in its own interest, but also as a contribution to the common stock. The observations are not difficult. Many are taken quite effectively in this country by lighthouse keepers, coastguards, sanitary inspectors, or gardeners, but they require unremitting care and honesty, and also supervision by a competent authority who will see that proper facilities are provided and punctuality duly kept.

In this respect an outlying district like the Dependencies of the Falkland Islands is of great importance, because it belongs to the area of which so little is known, and, within reasonable limits, no opportunity of establishing a centre of observations should be neglected. It should be under the supervision of someone at the Falkland Islands who can act as a meteorological expert. It might be necessary to send an expert there for a time to arrange the organisation. As a permanent arrangement the authorities in charge of the Dependencies in such a region should have as part of their training sufficient knowledge of meteorology and its methods to exercise the necessary supervision. The work of keeping the record should be regarded as an essential part of government, not as a piece of extra duty for a voluntary observer.

The information so collected would be unproductive unless it is regularly examined, collated, and discussed. Therein comes the co-operation of the home Government. Private individuals may show by occasional researches, as Mr. Mossman has done, that the investigation may lead to valuable results, but the investigation itself requires organisation which no private individual can provide.

It is sometimes urged that the people who inhabit a particular locality ought not to be expected to keep a record of their own weather, because they have enough local experience to enable them to manage their own affairs in an economic manner without keeping a record. That is a very short-sighted view. Particular persons, like the skippers of vessels, may know enough to enable them to make a sufficient profit for their employers, but that is not by any means the same thing as making the most of the resources of the country.

The experience upon which they act is either written or unwritten; if it is written it should be made available for the use of the Government, and it becomes the record required; if it is not written, then it is wasteful that the knowledge should disappear with the man who knows it. Moreover, this is a question of co-operation; no country is so completely isolated that in the long run it has no interest in other people's records. Nigeria, for example, has recently found its rainfall failing, and wishes to know whether the failure is likely to be temporary or permanent. There is no answer to the question from the records of Nigeria alone. All the world must share in questions that belong, as seasons do, to the world as a whole.

The plan, if it may be so called, which has been followed hitherto is to leave the meteorological survey of outlying districts to chance. The Meteorological Office, acting generally upon the advice of the Admiralty, was accustomed to lend instruments for observations on remote islands when someone in the locality expressed his willingness to act as observer. Instruments have been lent on these grounds for observations at a number of equatorial islands and to Tristan da Cunha, among other places. But the supervision at these distances is impossible for the Meteorological Office with its present organisation.

The regular return of meteorological observations is one of the requirements of the leases granted to whaling companies operating at South Georgia, the earliest of which dates from the 1st January, 1906. That is a considerable step in advance and only requires co-ordinating with a proper supervising organisation in this country to make an effective system.

2.—Antarctic Stations.

Sir Napier Shaw referred to the correlations recorded by Mr. Mossman in his pamphlet on "Southern Hemisphere Seasonal Correlations," and regarded the figures as most striking and impressive from the point of view of world meteorology. The period covered by the records is not, however, sufficiently long to afford positive proof of the relations; such proof would only be forthcoming if the results were confirmed by observations extending over a long time. Thirty-five years may be regarded, for the time being, as a normal period.

Asked whether he considered the continuance of such intensive observations, with a view to determining, if possible, the factors upon which world meteorology depends, to be of sufficient importance to justify the maintenance of an additional establishment in the Dependencies, say, at the South Shetlands, Sir Napier Shaw said that he had not been especially concerned with this question, and that he thought it doubtful whether Dr. Gilbert Walker, who had given special attention to the bearing of such correlations upon the weather of India, would regard such a station as a necessity from his point of view. As already explained, the Meteorological Office approached the matter of observations in a different way, i.e., from the point of view of a survey of the whole globe, for which two stations in the Falkland Dependencies seemed sufficient. The Meteorological Office already receives observations from Cape Pembroke, Falkland Islands, and from South Georgia. In addition there is the station maintained at the South Orkneys by the Argentine Government. In view of the importance of the polar regions observations from the far south are extremely valuable, and records obtained at a station at the South Shetlands, or better still, in Graham Land, would derive additional importance from the fact that these places lie farther south than the stations from which observations are at present being received.

As regards the possibility of assistance, financial or otherwise, being forthcoming for this purpose from the Meteorological Office, Sir Napier Shaw said that the difficulty is that the questions of meteorology cannot be divided into separate problems of a temporary character, and, in allocating the fixed grant at the disposal of the Office, it would be necessary to consider whether the money was already more profitably employed elsewhere than it could be in the Dependencies. He doubted whether the expense of establishing an additional station for intensive observations in the far south would be a justifiable charge upon the present "grant-in-aid" of the Meteorological Office, although if it were possible to obtain observations of the upper air by means of balloons it would be highly desirable.

3.—Ship Observations.

As regards the suggested employment of a research vessel, Sir Napier Shaw said that although the ship would be moving over a considerable area of ocean it would be very desirable to have a trained meteorologist on board. In this connexion he referred to Alexander Buchan's work on the results recorded by the "Challenger" expedition, which marked a definite step in the meteorology of the globe, and to the publication by the Board of Trade of the scientific results of the voyage of the "Scotia" in 1913, in which the work of Major G. I. Taylor marked another definite step in the development of dynamical meteorology. It was suggested that meteorological observations might perhaps be taken by a biologist or some other member of the scientific staff, after a few months of special training for the purpose, but Sir Napier Shaw said that he would not advocate this course, since opportunities for obtaining observations under such conditions occurred but rarely, and the employment of a trained meteorologist would be essential in order that the fullest possible advantage should be taken of such an opportunity.

In reply to an inquiry as to what assistance might be expected from the Meteorological Office in the event of such an expedition materialising, Sir Napier Shaw said that he would, for Imperial reasons, recommend most strongly that an expert meteorologist, furnished with special equipment, should be placed on board, and he hoped that before any such proposal was rejected the Meteorological Office would be afforded an opportunity of considering the question.

24th June, 1918.

APPENDIX XXIII.

METEOROLOGICAL NOTES.

Early meteorological observations in the regions embraced in the far southern Dependencies of the Falklands were entirely derived from the records of summer voyagers with instrumental equipment that, before the Dundee expedition of 1892-93, could only be described as inadequate. The most important results that emerged from these early data were the system of currents in the Weddell Sea accurately described by Weddell, the prevalence of north-east winds near the South Shetlands and west coast of Graham Land, and the lowness of the summer temperature and pressure. The German expedition of 1882-83 supplied the first complete year's observations from South Georgia, while Dr. Bruce made the first good series of summer observations (1892-3) in high southern latitudes. During the last twenty years observations made by various expeditions—Argentine, Belgian, British, French, German, and Swedish have all supplied those data for various periods and areas, the most important being those on Laurie Island, South Orkneys, founded in March, 1903, by Dr. Bruce, and continued under Argentine auspices since February, 1904. Valuable long records have also been kept at Cumberland Bay, South Georgia, since 1905, and at Cape Pembroke, Falkland Islands, since an earlier period The high-class observations at Cumberland Bay are not to be taken as a sample of the general quality of observations likely to be made at a whaling station, as the observer since July, 1907 (except during one or two brief periods), was a highly-trained member of the staff of the Ben Nevis observatory closed in the year 1904. Other members of the staff of that observatory were from time to time absorbed into the staff of the Argentine Meteorological Service, which pays the salary of the South Georgia observer and has been generally responsible for the upkeep of that station since July, 1907, when the quality of the observations, formerly taken by an official of "The Argentine Fishery Company," greatly improved. Other members of the Ben Nevis observatory staff have at various periods been in charge of the South Orkney observatory, and their unique experience has, as occasion offered, been incorporated into the general routine of that observatory, affording an ample guarantee as to the excellence of the general work carried on there. The practical utility of this work is gradually emerging, and the results have been found to be of value, among other factors, in predicting (1) the rains and height of rivers in Argentina, (2) the monsoonal intensity in India, (3) the temperature of Kimberley. There is also a strong inverse relation between the winter rainfall on the coast of Chile

in middle latitudes and the height of the Nile flood, which means that, if we could predict the Chilian rains, we could also predict the Nile flood, or, at any rate, use the data as one of the factors involved in its prediction. The most promising method of doing so would be the establishment of a permanent station on or near to Wandel Island in latitude 65° south near the southern end of Gerlache Straits. In this region two years' observations, taken by Charcot in 1904 and 1909, have indicated that there is a pronounced see-saw of pressure between the South Pacific anti-cyclone and the low pressure area in the Bellingshausen Sea of a similar nature to the pressure see-saw between Iceland and the Azores, which is the principal factor in determining the weather over Western Europe. Similarly, the see-saw between these two southern "action centres" sways the weather over Chile and the adjacent Argentine territories. The Wandel Island station appears to me to promise the best results. The establishment of a station on Tristan da Cunha or Gough Island, preferably the latter, is obviously so important in relation to South Africa and the Antarctic that it is unnecessary to press its initiation. A meteorological station on South Thule, or another island of the South Sandwich group, is also desirable, subject to its freedom from noxious volcanic emanations. A station on a northern point of the South Shetlands would also be of utility, not only for scientific purposes, but as a point which shipwrecked mariners might make for. May I be permitted to urge strongly that South Africa, India, New Zealand, and Australia be asked to co-operate in the work contemplated in the areas of the Dependencies of the Falkland Islands. New stations are specially required at such places as the Bouvet group, Crozets, Kerguelen, etc. At Macquarie Island, where the Commonwealth of Australia had a station (which may be continued), some important results have been obtained. Lieutenant Maury, more than sixty years ago, referring to the vast oceanic waste surrounding the South Pole, said: "It is a reservoir of dynamic force for the winds, a regulator in the grand meteorological machinery of the earth." A time has now come when meteorological results from the Southern Ocean and adjacent Antarctic areas are of economic application, quite apart from their general interest to students of the meteorology of the globe.

I need hardly say that I shall be only too willing to give the Committee and others any assistance in drawing up any scheme that may be initiated. Although merely an "outsider" from the point of view of British official meteorology, the study of the problems involved in the scheme outlined above has formed the greater part of my work during the last sixteen years. From 1902-1904 I was the meteorologist to the Scottish National Antarctic Expedition, remaining at Laurie Island for another year after the departure of the "Scotia" in February, 1904, and was the first superintendent of the South Orkney observatory under Argentine auspices. On arriving at Buenos Ayres in 1905 I remained some time preparing the Argentine data for publication, and saw the volume of South Orkney results (Volume XVI. of the Annals of the Argentine Meteorological Office) through the press. I then returned to Scotland and completed the Scotia results (Volume II., Physics, Scotia Reports), after which I returned to Buenos Ayres in October, 1907, remaining there till July, 1913, when Volume XVII. of the Argentine Annals, containing the South Orkney data for the period 1905-10, was completed, along with a general discussion of the whole series since March, 1903. Most of my spare time in recent years has been devoted to the elucidation of various problems associated with Arctic and Antarctic meteorology, and I have published numerous papers and memoirs on these subjects, both of which I have studied in the field.

R. C. MOSSMAN.

14th June, 1918.

APPENDIX XXIV.

(*a*) MEMORANDUM ON MAGNETIC OBSERVATIONS DESIRABLE IN THE NEIGHBOURHOOD OF THE FALKLAND ISLANDS.

It is important for navigation in these waters that the magnetic declination should be observed sufficiently for accurate charts to be prepared from time to time. The accuracy in this region of the 1917 Admiralty chart of declination is largely dependent on a voyage of the "Carnegie" in 1916. The secular magnetic changes necessitate continued observations, in order to keep the charts up to date.

Observations of declination made at sea will be of value, but, except in ships constructed to be non-magnetic, like the "Carnegie," the accuracy is not comparable with that attainable on land. Much importance, therefore, is attached to observations on each group of islands.

The observer should select more than one station on each group of islands in order to ascertain whether magnetic conditions are locally disturbed by presence of magnetic matter. If possible, stations where previous observations have been made, e.g., by the "Gauss" or the Scottish expeditions, should be chosen, and at all stations observations should be repeated after a few years, whenever it can be arranged.

It is specially necessary in disturbed localities that repeated observations should be made precisely on the original site.

For scientific purposes it is very desirable that, on land, dip and horizontal force should be observed as well as declination.

On Laurie Island, in the South Orkneys, there is a magnetic observatory started by the Scottish National Antarctic Expedition in 1903, and afterwards maintained by the Argentine Meteorological Office. It is uncertain whether this observatory is still being carried on. If so, the officer should get into touch with this observatory. Comparison observations made there would afford a valuable check on the field instruments employed.

If the observatory is not being continued, a site in its neighbourhood should be chosen as one of the stations.

As regards instruments, a magnetometer and dip circle will be required. It may not be necessary to obtain new instruments, as there are instruments in the charge of various public bodies which might be available.

It is very desirable that the officer in charge of the observations should go through a course of instruction in the use of the instruments. This could be best arranged for at the Kew Observatory under Dr. Chree's direction.

The magnetic observations should be forwarded to England as promptly as possible.

F. W. DYSON.

Royal Observatory, Greenwich,
19th June, 1918.

(*b*) NOTE OF INTERVIEW WITH Dr. S. CHAPMAN, OF THE ROYAL OBSERVATORY, GREENWICH.

The Committee had before them the above memorandum furnished by the Astronomer Royal, who had deputed Dr. S. Chapman to attend the meeting in order to give any further explanations that might be required.

Dr. Chapman read the memorandum to the Committee, and in the course of the discussion the following points were elaborated:—

1.—Non-magnetic ships.

Dr. Chapman said that an attempt was made to render the "Discovery" non-magnetic, but that the work was not so complete as in the case of the "Carnegie," which was rendered specially suitable for magnetic work by the elimination, as far as possible, of the use of iron in its construction. He recognized that the provision of a non-magnetic vessel would be a costly matter, and the Committee were not disposed to regard the idea as feasible, in view of the expense and of the other purposes for which the ship would be required. It was further noted that, as the vessel would frequently be in the neighbourhood of land, there would be numerous opportunities of obtaining the more accurate observations attainable ashore.

2.—Observations.

Dr. Chapman said that he would be glad to draw up, if and when required, a list of the localities in which observations were particularly desirable. He explained that lengthy observations were not essential; and that, if conditions were favourable, one complete set in any locality could be obtained in a single day, or even at night. It would, of course, be very valuable to have a permanent observatory to enable continuous work to be carried on, and for the purpose of checking the instruments as and when necessary. Means for such adjustment would, however, be available at the Observatory maintained by the Argentine Meteorological Office in the South Orkneys, one of the Dependencies which the vessel would no doubt visit from time to time.

As regards the suggestion that the officer in charge of the observations should have a course of instruction at the Kew Observatory, Captain Smith explained that the observations will be conducted by the naval officer in charge of the ship, who would, as a matter of routine, have gone through such a course as was suggested.

25th June, 1918.

APPENDIX XXV.

NOTES OF INTERVIEW WITH Dr. J. W. EVANS, ADVISER ON GEOLOGY TO THE COLONIAL OFFICE, AND Mr. J. F. N. GREEN, OF THE COLONIAL OFFICE.

Dr. Evans produced geological maps of South America and the Dependencies of the Falkland Islands, and said that he desired, in the first instance, to offer some explanation of the general geological structure of these areas, dealing in the first instance with Graham Land, which is situated almost exactly due south of Cape Horn. It is almost a reflection of the southern part of South America, and presents a most remarkable similarity to it. In both regions there are (1) an eastern tract of Cretaceous, Tertiary, and Recent strata, almost in a horizontal position, associated with basic volcanic rocks, and (2) a western tract of folded rocks. In South America the latter forms the southern end of the great mountain chain, usually referred to as the Cordillera, which stretches northward to Alaska. In each area the western tract is formed of three main ridges, the inner or eastern, the central, and the outer or western, the last being partly submerged and represented by a line of islands and peninsulas.

At the extreme north of the eastern ridge in Graham Land there are Jurassic rocks, which are of the same age as the Upper Gondwana or Karoo beds of India and South Africa, and similar beds in Australia and South America. In the Lower Gondwana or Karoo beds valuable seams of coal are usually met with, but even where coal occurs in the Upper Gondwana it is usually comparatively small in amount and poor in quality. The Upper Gondwana beds of Graham Land contain plant remains but no coal. It is not impossible that, by means of boring, Lower Gondwana beds might be reached below the Upper Gondwana and be found to contain coal, but the fact that coal has not been met with in South America south of latitude 40°, even where, as in the Falklands, Lower Gondwana beds occur, is not encouraging.

In the Cordillera intrusive rocks of a characteristic type, rich in lime, are found throughout the length of North and South America, and they also occur in Graham Land.

In the south of South America, auriferous deposits, chiefly alluvial, have been discovered at many points, and some work has been done on them, though no results have yet been obtained comparable to those of the more important auriferous areas in other parts of the world. It is probable, therefore, that gold will also be found in Graham Land. Copper has been reported from the central and western ridges of the Cordillera, and it is interesting to note that a specimen of copper ore was found by Mr. Wilson at the foot of a glacier near Port Lockroy, in the Neumayer Channel, on the west coast of Graham Land. The glaciated condition

of this country would place serious difficulties in the way of the opening up and exploitation of its mineral wealth, but these should not prove insuperable provided valuable deposits are discovered, especially in the case of gold.

The South Shetlands appear to be closely related to Graham Land, and, so far as present observations go, they are essentially of the same geological character as the other islands to the west of Graham Land, but differ from them and from the islands west of Patagonia in being situated farther from the mainland.

Starting from Staten Island, one finds a series of islands situated on a curve convex to the east, extending to Graham Land. These include the Shag Rocks, South Georgia, the South Sandwich Islands, and the South Orkneys. The islands are isolated elevations and do not represent a continuous submerged ridge, since there is deep water between them.

South Georgia has an elongated shape and lies west-north-west and east-south-east. The oldest rocks, the Cape George Series, are probably of pre-Cambrian age, and are overlain unconformably by the Lower Cumberland Bay Series, which has yielded fossils of Ordovician or Silurian types. Superimposed again on these, probably unconformably, are the Middle and Upper Cumberland Bay Series, which are apparently of Jurassic age, and are largely made up of volcanic tuffs. Intrusive igneous rocks also occur, but are subordinate in importance.

The South Sandwich Islands consist of basaltic volcanic accumulations of comparatively recent age. Sulphur occurs as a cement of volcanic breccias, and it is possible that it might be of economic importance.

The South Orkneys resemble South Georgia in their geological features, except that pre-Cambrian and Jurassic rocks have not been recognised.

Dr. Evans said that, after carefully considering the evidence, which had been much discussed, he was inclined to believe that the idea that South Georgia and the South Orkneys belonged to the same line of earth folding as the Cordillera of South America and Graham Land had some foundation in fact. In any case, South Georgia and the South Orkneys, as well as the whole Graham Land region, are worth prospecting, and might not unreasonably be expected to yield evidence of metalliferous deposits, especially gold. Gold, too, is more likely to be met with in payable amounts, for under normal conditions its value is practically constant, while other metals have to compete with rich deposits throughout the world.

The most important contribution up to the present to our knowledge of the geology of Graham Land and the adjoining islands, dependencies of the Falklands, is a paper by J. Gunnar Andersson, published in English in the *Bulletin of the Geological Institution of the University of Upsala*, Volume 7, pages 19-71 (1906). It is mainly based on the author's personal observations, and contains abstracts of the previous literature. Dr. Nordenskjöld's contribution to the *Handbuch der Regionalen Geologie*, published in 1913, also contains a brief account of the work that had been done up to that date. Much valuable information with reference to the geology of South Georgia and its relation to adjoining areas will be found in articles by D. Ferguson, G. W. Tyrrell, and J. W. Gregory in the *Transactions of the Royal Society of Edinburgh*, Volume 55, pages 797-836 (1915). These were founded on specimens collected by Ferguson. They were followed by some notes by Tyrrell in the *Geological Magazine* for 1916, pages 435-441, on other specimens from South Georgia. Finally, there is an important unpublished report by H. H. Thomas, Petrologist to the Geological Survey, on rocks collected from the South Shetlands and Graham Land by J. Innes Wilson. Additional information on rocks from these localities will, it is understood, be shortly published by D. Ferguson and G. W. Tyrrell.

As regards the method of investigation Dr. Evans expressed the opinion that it would serve no very useful purpose merely to collect specimens, as matters would not be advanced much farther by such means. It would be better to engage a trained geologist, who would be ready to take full advantage of his opportunities. His duties would involve hard work in climbing the hillsides and investigating along the shores from the points where the expedition called, and the geologist selected should be of athletic habits. Owing to the swell it would be impossible to carry out satisfactorily a survey of the coast from a boat. He should have an eye for structure, and sufficient experience to recognize in most cases rock types on the ground. No collection of specimens, however large, could be regarded as a substitute for this. In some instances in which reliance was placed on the subsequent examination of specimens, their loss by shipwreck has been an irreparable misfortune.

Referring to geophysical researches not primarily geological, Dr. Evans stated that magnetic observations were important, and might give indications of the presence of iron ores, and also afford some idea of the structure of the country. Observations as to the force and direction of gravity at particular stations are important, especially in this area, but they require special apparatus and take time. The same considerations apply to seismological observations. Probably a careful topographical survey on land (as well as the hydrographical survey that is, he understands, contemplated) is more important at the present stage, as it is not only urgently needed in connexion with the geological survey work, but it is a necessary preliminary to future investigations in other directions. There is an immense amount of work to be done on the scientific side in this part of the world which is of the greatest interest, and it is always possible that such work may lead ultimately to results of economic value.

In reply to a further inquiry by Mr. Lyon as to the possibility of finding coal, Dr. Evans said that the prospect was not promising, but that if coal were found it would probably be in sufficiently large quantities. The high latitude in which the Dependencies are situated is not in itself an argument against the discovery of coal, which has been found much farther south on the other side of the Pole in Victoria Land, which, however, in view of its geological resemblance to Australia and Tasmania, affords much better prospects than territories like the Dependencies which are similar in their features to South America. He added, in reply to a further question from the Chairman, that geologically the Falkland Islands were more closely allied to South Africa than to South America.

As regards the selection of a geologist Dr. Evans considered that the best type of man for the work would probably be a Canadian with a knowledge of the rocks of British Columbia, especially if his experience had also extended to the Klondyke.

Questioned by Mr. Borley as to the possibility of finding valuable minerals such as tungsten or radium. Dr. Evans said that tungsten had not been discovered in Patagonia, but had been in Peru, Bolivia, and Argentina. Deposits of minerals containing uranium, from which radium is derived and with which it is associated, had not been reported from Patagonia or Argentina. Vanadium, a rare element which it pays to work even in very small amounts for the manufacture of vanadium steel, had been found in South America, the richest deposits being in Peru, where it appeared to have been precipitated from solution by carbonaceous matter. It was frequently found associated with copper in formations similar to those in the Dependencies. While it is possible that valuable ores might be discovered in the Dependencies, it should be remembered that, except in the case of gold, it is only comparatively large deposits of minerals that pay for working—at any rate, in peace time.

Mr. Borley inquired whether, if facilities were given for a specialist in geophysical work to accompany the expedition, it was possible that any organization would be willing to supply a man with the necessary equipment and to finance the work. Dr. Evans thought that, in view of the unequalled opportunity which would be afforded, it was not improbable that after the War the Topographical Survey of England, Canada, or India would be glad to take advantage of the opportunity and second a man for service with the expedition.

In reply to the Chairman, Dr. Evans said that he would not recommend the setting up at the present stage of elaborate plant for boring for coal. This could best be carried out if a whaler landed the men and plant at the beginning of the Antarctic summer and fetched them away at the close of the season.

Mr. Green laid the appended memorandum before the Committee and emphasised the fact that existing knowledge with regard to the geology of the Dependencies of the Falkland Islands is very general, and much of it of a doubtful character. It is even possible, for instance, that in South Georgia the Cape George rocks, instead of being oldest, are among the youngest. It is not to be expected that investigations in the Dependencies would at first lead to such valuable economic results as similar operations in more settled Colonies. It was very desirable that any investigations should be systematic and not be confined merely to the collection of specimens. The discovery of coal or some other form of fuel would be of enormous value, in view of the requirements of the whaling industry, which at present had to be supplied from this country. Investigation of the plant-bearing beds is

therefore of great importance. No indication of oil-bearing shale had been found in the Dependencies, but a specimen had been discovered in the Falkland Islands, although it was not known how it occurred; one opinion being that the specimen was washed ashore. The geological work is, however, not of such importance as the biological and hydrographic work in contemplation; and, in any case, borings and elaborate geological work should not be taken in hand in the first instance until a more general survey enabled favourable spots to be indicated. Although prospecting for coal and valuable ores was of importance, the need for accurate geological maps should not be overlooked. Such work was part of the ordinary duty of a Government. It was desirable that any geologist engaged should have a certain amount of experience of geological survey work in the field.

MEMORANDUM BY MR. J. F. N. GREEN.

OUR knowledge of the geology of the Dependencies of the Falkland Islands is, unfortunately, mainly due to foreigners. There is an excellent abstract up to 1913 by Dr. Nordenskjöld in the *Handbuch der Regionalen Geologie*, VIII. Band, 6 Abteilung, with a bibliography. With the exception of certain petrographical descriptions, little of value has been added since that date.

The geology is extremely varied in formations, structure, and rock types. Numerous well preserved fossils have been found. It is thus of special scientific interest and some economic promise.

The most valuable discovery would be some form of fuel, capable of supplying the whaling industry; coal, oil, or oil-shale. The possibility of such is indicated by:

(1) The existence of Permo-carboniferous strata in the Falkland Islands, with traces of plants.

(2) Plant-bearing Jurassic strata at Hope Bay.

(3) Plant-bearing Oligocene strata at Seymour Island.

Coals are known in the southern hemisphere of each of these ages.

On the other hand ordinary industrial minerals, such as limestone, sands, road-metal, etc., which are plentiful in the Dependencies, are of no particular use in the circumstances. Ores could be worked, if so favourably situated as to compensate for the heavy expense of labour and the restrictions imposed by the climate. At present, however, the only undoubted example of high-grade ore is a specimen of copper ore from Graham Land.

It is suggested that it is desirable that geological investigation should be undertaken both for industrial and for purely scientific reasons; that the work should be on survey lines, that is, that the ideal aimed at should be the production of continuously improving geological maps, the method being the accumulation of data under Government control. The specimens, note-books, etc., should remain Government property and be preserved with all other records in some institution. One of the Scottish Universities would probably be glad to provide accommodation.

Valuable as such research would be, it is clearly not of the same importance in the Falklands as biological investigations, and, at all events at present, must grant precedence to hydrographic and meteorological work. The amount of attention to be devoted to it must depend on the staff available after more important needs have been provided for. But, if it does not prove possible to appoint a geologist, it ought to be arranged that one of the meteorologists has geological qualifications and is enabled to spend a part of his time on this work, so that the opportunities afforded are not lost altogether. As knowledge of the structure and age of the formations increases, it will become in time possible to appraise better the chances of useful discoveries and to select spots for boring or other special examination.

APPENDIX XXVI.

REPORT OF THE SHIP SUB-COMMITTEE OF THE COMMITTEE ON THE DEPENDENCIES OF THE FALKLAND ISLANDS.

As scientific and economic researches in the Dependencies would necessarily involve the employment of a special vessel for the purpose, we were appointed by the main Committee to serve as a Sub-Committee to investigate the type of vessel and equipment required.

As a guide to us in our deliberations the main Committee agreed provisionally that, in addition to the navigating and survey staff, cabins would he required for a

permanent staff of not less than five scientists. A medical officer would be required, but this post might possibly be combined with one of the biological appointments. Also some spare accommodation should be available for additional temporary staff.

On this basis we took into consideration in the first instance the possibility of employing a vessel of 1,200 tons. It appeared, however, that such a vessel would be an impracticable size for many of the purposes in view, and, in particular, for work in or near ice. We then considered as an alternative the employment of a smaller vessel of 900 tons; but this proposal was open to the serious objection that the accommodation available would be substantially less than the minimum contemplated by our instructions, and we therefore proceeded to consider a further suggestion, namely, the employment of two vessels of still smaller size.

We were advised that the employment of two small vessels instead of a single large vessel would involve little if any more expense, especially as considerable economy would result from the fact that only the smaller of the two vessels would require to be fully equipped for work in heavy ice. In the case of the larger vessel it would be necessary to provide special protection at the bows and stern only. Also, in addition to many other important advantages,* the employment of two vessels would obviate the necessity of unduly restricting the staff of the expedition owing to the lack of adequate accommodation.

We therefore decided to make an interim recommendation to the main Committee that we should proceed on the assumption that two vessels would be employed, one being about the size of the "Endeavour" (700 tons net), and the other of similar size to the "Scotia" (215 tons net). The vessels should work in intimate connexion with each other (the smaller being rather in the nature of a tender to the larger), and they should both be equipped with wireless installations for intercommunication.

This recommendation having been accepted by the main Committee, we accordingly considered specifications for the two vessels contemplated, and now recommend as follows :—

Larger Ship.—This vessel should be a wooden vessel with steam power, of about 700 tons net. The draught should not exceed 15 feet. In view of the difficulty of obtaining crews accustomed to square rigs, the vessel should be a three-masted topsail schooner rather than a barque, since a vessel with the former rig has the advantage that it can be sailed as a fore and aft vessel until the crew gain experience of square sails.

The propeller should be capable of being lifted, and the rudder should be of the balance type. We have discussed the question whether it would be necessary to provide means of lifting the rudder, as was the case in the "Pourquoi Pas," but, in view of the fact that there is no record of its having been lifted in that ship, and its probable liability to accident, it is not recommended for use in either vessel.

Special ice protection should be provided, extending 25 feet from the stem and 15 feet from the stern; in these regions it should run from the keel to 2 feet above the water line, and the wood should be oak, 7 inches thick. About 6 feet on each side of the stem should be further strengthened by wrought iron plating. The remainder of the ice protection should be covered with a layer of greenheart, which is less liable to tear than other timbers.

As regards accommodation, the officers' cabins, a sick bay, and a large laboratory should be before the funnel. There should be at least ten cabins besides the captain's cabin. The large laboratory should be on the upper deck and have an area of about 140 square feet; and there should be a smaller laboratory with an area of 90 to 100 square feet, if possible also on the upper deck. Dr. Bruce's experience in the "Scotia" led him to attach great importance to placing the large laboratory on the upper deck in order to secure natural light; and he had found that for physical observations the temperature could be quite well controlled in a deck laboratory.

The chart room will serve also as study and scientific library. It should be at least 150 square feet in area, and might be abaft the funnel.

A small wireless telegraph room will be required, and might be placed abaft the small laboratory.

There should be a photographic dark room between decks.

A felt lining for the interior is not necessary, but bolt-heads should be corked if they communicate with the exterior.

* See paragraph 141 of the Report of the Main Committee.

The speed of the vessel should be ten to twelve knots, there should be bunker accommodation for 500 tons of coal, and accommodation for about 100 tons of fresh water.

The following boats will be required : two motor-boats with engines as silent as possible, speed nine to twelve knots; four whalers and one or two Norwegian prams; at least two detachable motors of the Evinrude or other good make. Storage will be required for motor spirit.

The vessel should be heated by hot air, and provided with electric light and electric power for the wireless installation.

Smaller Ship.—This vessel should be about 230 tons net and 14 feet draught. It should have a special ice protection along the whole length of the ship from the keel to 2 feet above the water line. The main timbers should be of 7 inch oak, with a lining of 7½ inch oak in addition. The bolts should run right through both layers of oak; there should be a greenheart skin separately bolted. The bow protection of wrought iron should be similar to that of the larger vessel, but of about double the thickness. A memorandum giving an account of the ice protection of the hull of the "Scotia" is appended, together with a plan showing the bow protection.

As regards accommodation, there should be seven cabins besides the captain's cabin, and two laboratories, one on the upper deck before the funnel, 80 square feet in area, and one on the main deck, 60 square feet in area, or if possible larger.

The chart room should be about 100 square feet in area on the upper deck, and might be abaft the funnel.

The speed should be about ten knots, and the bunker accommodation sufficient for 200 tons, or as near to that figure as possible. There should be accommodation for 30 tons of fresh water.

The boats should consist of one small motor-boat, two whalers, one dinghy, and one pram, with two detachable motors.

In other respects our remarks with regard to the larger ship will apply also to the smaller, particularly as regards rig, heating, electric light, wireless installation, and dark room.

No sick bay will be required for the smaller vessel.

Equipment.—We append a list of the technical equipment required, and we recommend that ice tackle and explosives should also be included. A platinum resistance thermometer would be a desirable item of equipment, subject to its being found possible to maintain proper electrical connexions. The platinum thermometer failed upon the "Scotia" because such connexions could not be maintained. A small portable hut and two double tents should be carried on each vessel. Two hand sledges should also be provided, but dogs would not be necessary.

It is recommended that fur sleeping bags, finnesko and crampons, and wolf-skin mits, as well as ski and boots, and primus cookers should be provided, and that these should be landed along with any shore party who may be out to make investigations. Even if the contemplated stay is for a brief period it is desirable while at work in Sub-Antarctic or Antarctic regions that any shore party should have adequate protection in the event of the sudden advent of bad weather or ice conditions rendering the vessel unable to maintain her position, so as to take the shore party off. A drill tent and floorcloth should also be sent ashore, along with a supply of food and fuel.

Plans.—It has not been considered necessary to prepare plans of the proposed vessels, nor to recommend builders, as we consider it desirable to leave these matters to the Admiralty and the Advisory Committee that it is assumed will be appointed to control the expedition.

Cost and Maintenance.—While it is impossible, under existing circumstances to give any accurate estimate of the first cost and maintenance of the proposed vessels, inquiries have been made which indicate that the first cost of the two vessels would amount to about £85,000, and the maintenance to from £25,000 to £30,000 per annum, exclusive of the cost of the scientific staff.

CHAS. V. SMITH
(Chairman).

H. T. ALLEN,
Secretary.

June, 1919.

Memorandum as to Ice Protection of the "Scotia."

The "Scotia" had the following protection extending her whole length :—

Inside her frame was a planking of Norway red pine, the limber strakes being 11 inches thick, thence to the bilge $6\frac{1}{2}$ inches to $7\frac{1}{2}$ inches thick, from bilge to lower deck $7\frac{1}{2}$ inches to $11\frac{1}{4}$ inches thick.

Outside her frame, from keel to bilge, there were two layers, each $3\frac{1}{2}$ inches thick, of Norway red pine and Baltic pine respectively. From the bilge to the upper deck there was 7 inches of pitch pine and larch.

A $2\frac{1}{2}$-inch greenheart sheathing was placed outside this, from about 9 feet from the keel to a little above the water line; this sheathing, however, extended right down to the keel for about 18 feet from the forefoot. In addition, wrought iron bands, 9 inches wide by $\frac{3}{4}$ inch thick, were bent round the stem and carried back 4 feet 9 inches on each side from the top of the greenheart sheathing to the keel.

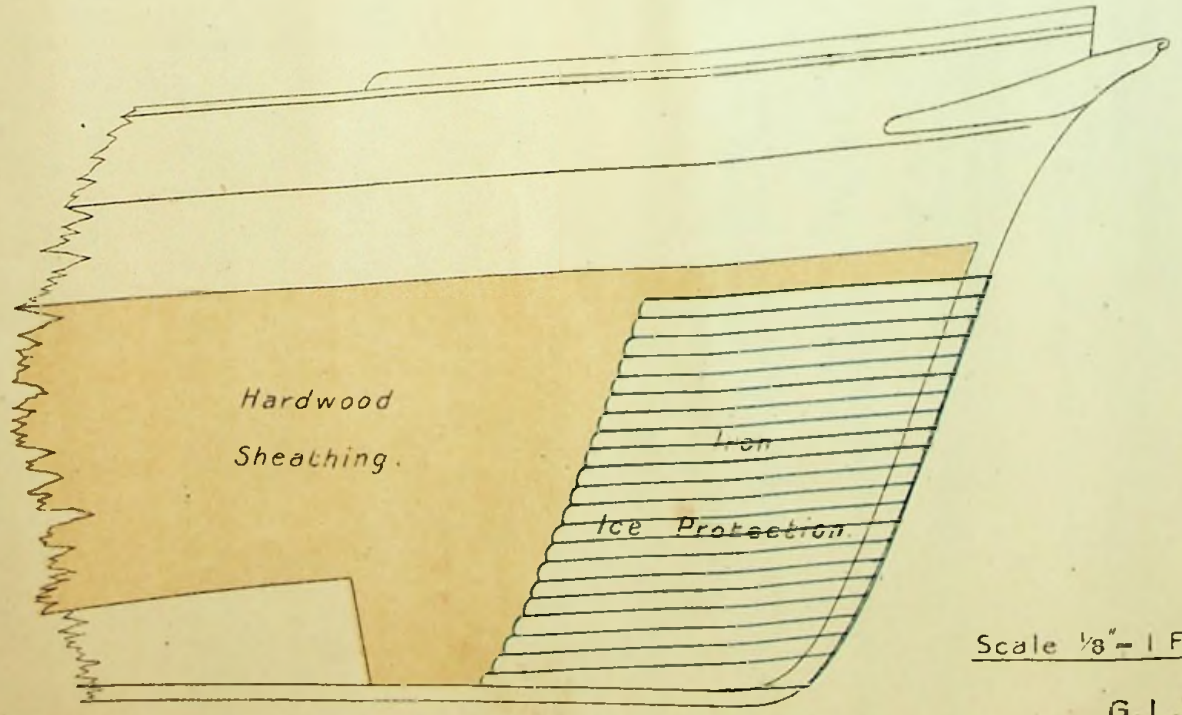
General List of Scientific Material Recommended for the Larger Research Vessel, to be Repeated in Most Cases for the Smaller Vessel.

1. Trawling winch, 50 h.p.
2. Fast winch for Lucas machine.
3. Ordinary trawling derrick.
4. Goose neck trawling and trap derrick.
5. Trawling cable drum.
6. Trawling meter.
7. Trap cable drum.
8. 6,000 fathoms trawling cable (Bullivant's galvanized steel wire ropes, $1\frac{3}{4}$ inches to $1\frac{1}{4}$ inches, tapered).
9. Twelve lengths, each 500 fathoms, of $1\frac{1}{8}$ inches flexible steel wire rope, specially shackled.
10. Two lengths, each 500 fathoms, $1\frac{1}{2}$ inches flexible steel wire ropes.
11. Four trawling blocks, with twelve spare rollers.
12. Large trap buoy.
13. Twelve small buoys, cork.
14. Two Lucas sounding machines, 5,000 fathoms and 400 fathoms.
15. Additional sounding meter and block.
16. 20,000 fathoms sounding wire, $20\frac{1}{2}$ inches gauge.
17. Sounders with long tubes.
18. 500 weights (28 lbs.) for sounding.
19. Six Lucas common leads.
20. Six Lucas snapper leads.
21. Two key sounders.
22. One large and two small double-handed trawls.
23. Three otter trawls, 50 feet; also two commercial trawls of 90 feet headline, one fitted with fine meshed netting at the cod end. Spare netting for the last named.
24. Two otter surface trawls.
25. Two Petersen Young fish trawls.
26. Two ordinary dredges; two conical dredges and two triangular-mouthed dredges for shallow water.
27. Two polyhedric traps.
28. Small traps.
29. Supply of sieves of standard sizes with circular neck.
30. Twelve zinc trawling tanks.
31. Three plate glass photographic tanks.
32. Townets, various.
33. Townet line knob.
34. Townet ring.
35. Vertical nets.
36. Milled silk and coarse meshed muslin or net.
37. Twelve reversing water bottles.
38. One full speed water bottle. Knudsen's pattern.
39. Two large size water bottles for moderate depths.
40. Deep sea thermometers.
41. Four reversing bacteriometers.
42. Two current meters.

SKETCH OF THE BOW OF THE S.S. "SCOTIA",

(SCOTTISH NATIONAL ANTARCTIC EXPEDITION)

SHEWING THE ICE PROTECTION.



Scale ⅛" = 1 Foot.

G.L.WATSON & Co,
Naval Architects,
Glasgow.
No 381.
28th Dec. 1918.

9519. 42708. 389. 1650 3. 20

Malby & Sons Lith.

43. Two photometers.
44. Two hydrometers with beakers.
45. Two total immersion hydrometers.
46. One large deck electric motor or steam centrifuge.
47. Laboratory hand centrifuge.
48. Many drift floats.
49. Two spring balances, 500 lb. and 150 lb.
50. One small ordinary balance.
51. Chemical balance.
52. Three binocular microscopes, Greenough type.
53. 2,000 gallons alcohol (industrial).
54. Drums for alcohol, ten gallons each.
55. Pump for alcohol drums.
56. 100 gallons Formalin, kegged.
57. Chemical material for biological and physical purposes.
58. Full bacterial outfit.
59. Swing tables for laboratories.
60. Suspended tables for laboratories.
61. Storing bottles and tubes with fitted cases for transport and stowage.
62. Microscope slides and cover glasses.
63. Photographic outfit.
64. Sinks for hot and cold water supply in laboratories and dark room.
65. Searchlight for pelagic fishing purposes.
66. Log sheets and data books.
67. Drift nets (various mesh), long lines and hand lines.
68. Two meter wheels with counter blocks.
69. Spring hooks for connecting up hydrographic apparatus.
70. Leather buckets, copper riveted.
71. Releasing device for working drift nets or water bottles, and messengers for the same purpose.
72. Electric torches with spare batteries.
73. Bottles for water samples, Allsopp's lager type in two dozen cases, with compartments and padded lid.
74. Labels for water samples.
75. Tallow and neat's foot oil for lubricating.
76. Pump and flexible hose.
77. Stop watches.
78. Large black trays for Plankton organisms.
79. Standard sea water.
80. Brine freezing installation.
81. Small canning plant for use at South Georgia.
82. One automatic tide gauge.

In the above list, in most cases exact details of pattern, etc., have been avoided, as it is considered that these would be best decided by the Advisory Committee.

METEOROLOGICAL INSTRUMENTS SUGGESTED FOR EACH SHIP, BY MR. R. C. MOSSMAN.

1. Two Kew marine barometers graduated in millibars.
2. Four dry and four wet bulb thermometers, graduated in 0° Fahr. scale from minus 40° to 110° Fahr., also Assam's aspiration psychrometer.
3. Two small single louvred screens as supplied by Meteorological Office for use at sea.
4. Two Richard barographs graduated in millibars.
   Two Richard suspensors for same.
5. A large Stevenson screen to be placed near the "cat head" might be supplied, to contain a small Richard thermograph and hygrograph on
   Richard suspensors. Duplicates to be kept in reserve.
6. Maximum and minimum thermometers graduated to minus 60° Fahr. and a Robinson anemometer.
7. Stationery and charts for barograph, thermograph, and hygrograph, etc.
8. A rain gauge for use at sea might also be supplied.
9. Outfit for upper air work.

APPENDIX XXVII.

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