CHAPTER X.

From Kerguelen to McDonald Islands and Heard Island—Notes on the reproduction of certain Echinoderms from the Southern Ocean—Heard Island to the Antarctic Circle and Australia—Icebergs of Antarctic Regions.

Kerguelen to McDonald Islands and Heard Island.

On the 2nd February, the day after leaving Kerguelen Island, the weather in the forenoon being fine and clear, a successful sounding and dredging were obtained in 150 fathoms, on a hard bottom (Station 150). The bottom was covered with a coarse gravel; the dredge brought up a large number of stones, fragments of rocks of irregular form, varying in size from 1 to 7 centimetres in diameter, with the angles more or less rounded, but much less so than those of ordinary rolled pebbles. They were blue-black, and the majority had a compact structure and were fine grained, while others were porous with a rough surface. Macroscopically they appeared to be basalts or basaltic lavas, but examined with the microscope it was seen that they belonged to the felspathic basalts (dolerite); among these volcanic fragments were noticed two or three pieces of granite and one of sandstone. The majority of these stones were overgrown by Foraminifera, Sponges, Actiniaria, Brachiopods, Ascidians, *Serpulæ*, and Polyzoa.

The dredge procured representatives of nearly all the invertebrate types. In the zoological Reports already published there are described twenty-two new species and three new genera from this locality. Of these there are seven new species of Tunicata including a new genus; seven new species of Gasteropoda, including a new genus, four new species of Ophiuroidea, and a new genus of Actiniaria. At noon the ship again proceeded under sail towards Heard Island, but at 1 P.M. a dense fog came on, so that at 3 P.M. it became advisable to bring to on the port tack under double-reefed topsails, as it was deemed imprudent to proceed further, not only on account of the uncertain position of the islands, but also because it is no unusual thing for icebergs to be seen in this locality; in fact the captains of the whaling schooners met at Kerguelen said that they passed two on their passage from Heard Island in January. At 5 P.M. no bottom was obtained at 425 fathoms, but at midnight a sounding was obtained in 92 fathoms.

On the 3rd February, at 6 A.M., bottom was again obtained in 80 fathoms, but previously, at 1, 2, 3, and 4 A.M., ground was not struck with 130 fathoms of line. This indicates the rocky, uneven nature of the bottom between Kerguelen and Heard Islands. As the weather remained thick and foggy all day, it was impossible to prosecute the search for Heard Island. The wind was light and variable with a long westerly swell. The fog lifting for a few minutes at 9.30 A.M., an observation of the sun was obtained.

On the 4th, at 4.30 P.M., the ship wore and stood to the southward, with the intention

of getting into the parallel of Heard Island and then steering east. At 10 A.M. the fog lifted and an observation was obtained. The weather remained fine during the afternoon, and the evening was quite bright and clear, which enabled the men to dry their wet clothes, the ship's sails, and decks. Unfortunately the wind was very light, so that the vessel was unable to make much progress towards the island under sail, and coal could not be afforded for steaming. At 3 P.M. no bottom was obtained at 120 fathoms, nor at 11 P.M. at 130 fathoms. During the afternoon the ship was surrounded by Penguins, uttering their discordant cry.

On the 5th, at 3.30 A.M. (daylight), sail was again made to the southward; but unfortunately, at 7 A.M., the weather became as thick as ever. As at this time the ship was on the supposed parallel of Heard Island, Captain Nares stood on to get to the southward of it before "laying to" again, trying for soundings at 7.30 A.M. with 200 fathoms of line, and at noon with 300 fathoms without success. At noon sail was shortened and the ship brought to the wind. At 1.30 P.M. the mist and drizzle broke slightly, and what was thought to be land was seen in an E. by S. direction. Towards evening the breeze died away, and at 9 P.M. a westerly wind sprang up, which freshened to a moderate gale by midnight, but also fortunately dispelled the fog.

On the 6th, at 3.40 A.M., the vessel bore up for the supposed position of Heard Island, the weather fairly clear with a westerly gale blowing. At 6 A.M., just as observations were being obtained, the M^{c}Donald Islands were seen through the mist bearing east, distant about 13 miles. A course was immediately shaped to pass round their northern side, in fact to circumnavigate them as nearly as the direction of the wind permitted; and the horizon being clear and the sun breaking frequently through the clouds, it was possible to fix their position accurately, as, besides other observations, a longitude was obtained when they bore south, and a latitude when they bore west, and the islands are so small that little beyond this was required.

M^{c}Donald Islands.

The M^{c}Donald Islands, 24 miles west of Cape Laurens, the northwest extremity of Heard Island, consist of two small islands, N. by E. and S. by W. (true) from each other, and an outlying sugar-loaf rock named Meyer's Rock, 1 mile N. 50° W. (true), from their north extremity; the islands are very small, and appear to be inaccessible. They were discovered by Captain M^{c}Donald of the British ship "Samarang," in January 1854. Captain M^{c}Donald also sighted Heard Island, but as it had been originally seen by the "Oriental," it bears the name of her captain.

Meyer's Rock, 450 feet high, is in lat. 53° 1′ 20″ S., long. 72° 30′ 30″ E.; the highest part of the M^{c}Donald Islands is a saddle hill, 630 feet high, the two peaks of which are in line on a north and south bearing. The channel between the two M^{c}Donald Islands

is only about a cable in width. Seen from a distance these islets appear three in number, as a low neck of land joins the N.E. and S.W. points of the larger of the two islets, and is only distinguished on a nearer approach. Rounding this group, at a distance of from 3 to 5 miles, no off-lying danger could be detected, either from the masthead or deck of the Challenger.

Since the discovery of the M^{c}Donald and Heard Islands, they have been frequently sighted by passing vessels, and until a knowledge of their existence was widely disseminated, each captain who saw them looked on them as unknown land. In 1857 Captain Meyer, of the German ship "Rochelle," was apparently not aware of their existence, and gave an account of them as unknown islands, which was published by Dr. Neumeyer in Petermann's Mittheilungen for 1858.

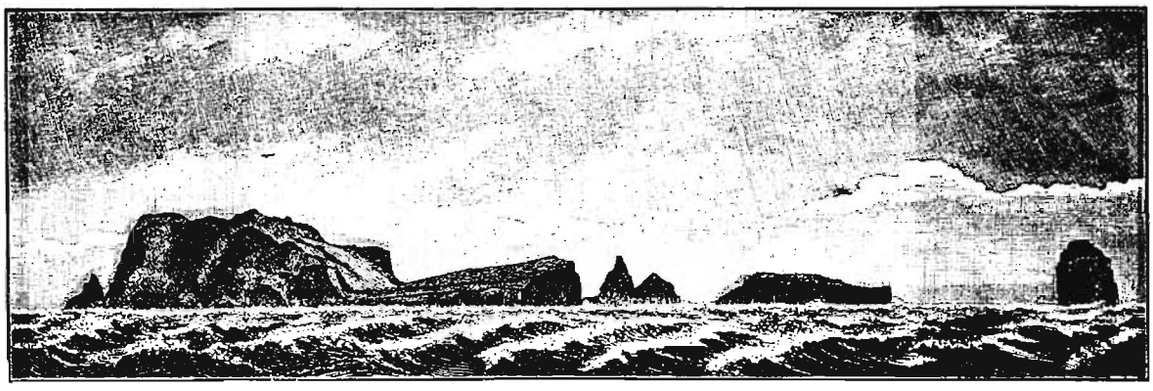


FIG. 134.—M^{c}Donald Islands and Meyer Rock, as seen from H.M.S. Challenger, 6th February 1874.

HEARD ISLAND.

Having rounded the M^{c}Donald Islands, and obtained a sounding of 105 fathoms, hard ground, 4 miles eastward of them, the ship was steered S. $\frac{1}{2}$ W. (S.E. true) for the supposed position of Heard Island. At noon the northern end of Heard Island was sighted and the course altered to pass round it, other observations of the sun being obtained at 2 P.M., when Red Islet, off its north point, bore south. Steering along the east coast the vessel eventually anchored in Corinthian Bay at 3.40 P.M. in 10 fathoms. A gale of wind blew all day, and the squalls off the high land of Heard Island were very violent, raising large quantities of spoondrift; in Corinthian Bay the wind was steady, both in direction and force, as it came over low land, which connects the high northwest promontory with the main island. The weather though not foggy was misty, for Shag Island was not seen until the ship was anchored in the bay. Clouds completely covered the high land, above the height of 1000 to 1500 feet, but the lower hills and the M^{c}Donald Islands were clear, so that their heights could be ascertained.

Heard Island[1] (see Sheet 22), discovered by Captain Heard of the American ship "Oriental" in November 1853, is of considerable extent, being 25 miles in length, and 9 miles in width, occupying an area of 100 square miles. Its northwestern extremity (Cape Laurens) is in lat. 53° 2′ 45″ S., long. 73° 15′ 30″ E., and its southeastern in lat. 53° 14′ S., long. 73° 52′ E.

The summit of the island was not seen from the Challenger, but is estimated as being at least 6000 feet above the level of the sea; the mountain is called "Big Ben" by the sealers, and from it large glaciers descend, and in many places reach the sea; but, as the temperature of the surface water is above 32°, the waves dashing against the edge of the glaciers wear away the base, and so form overhanging ledges of ice, which break off by their own weight when forced sufficiently forward by the gradual descent of the glaciers. Here and there low hills, separate from the main mountain mass, offer an obstruction to the ice, and prevent its covering the land on their lower

FIG. 135.—Glacier, Corinthian Bay, Heard Island, as seen from H.M.S. Challenger, 6th February 1874.

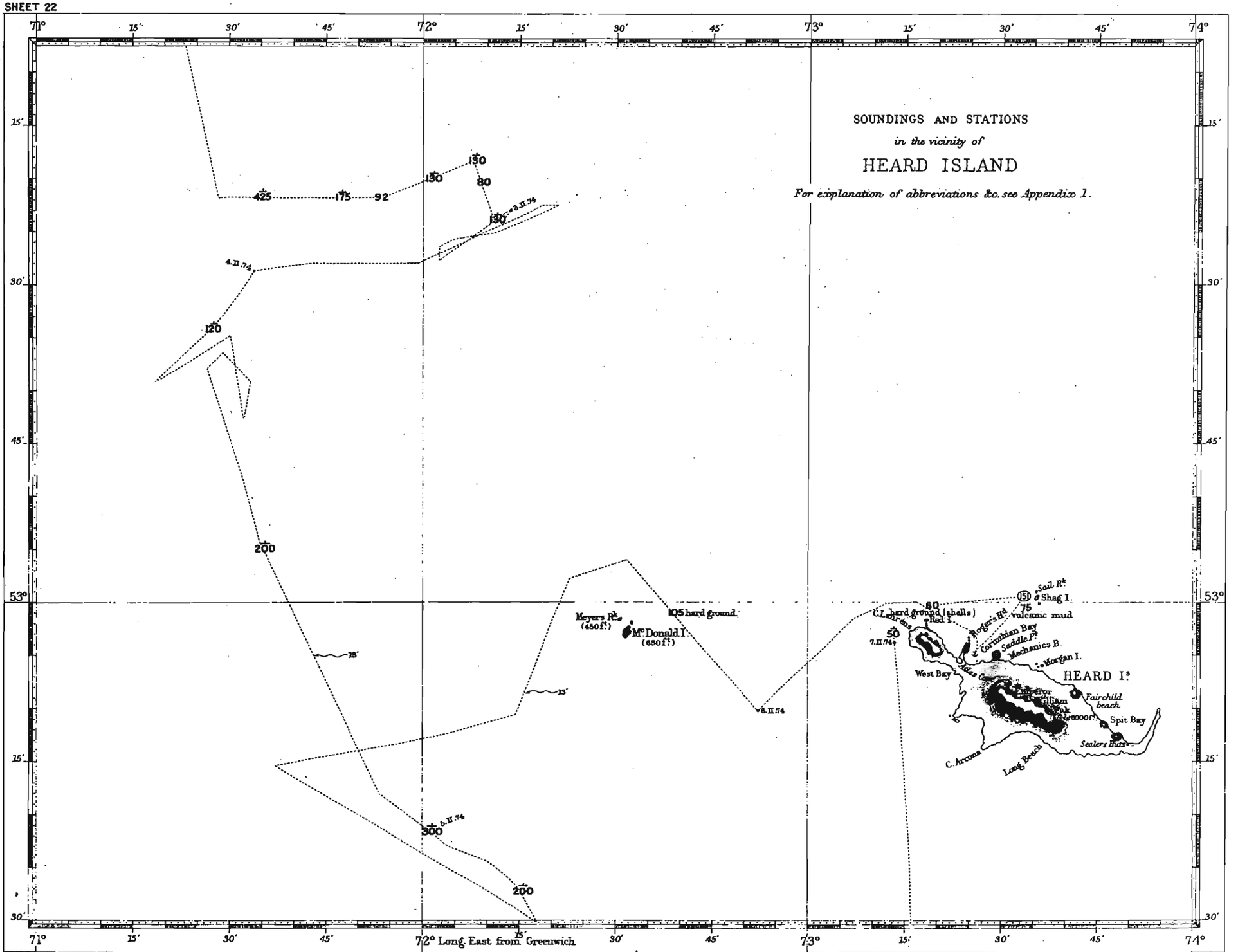
sides; such a hill blocks the glacier on the southeast side of a narrow low isthmus 5 miles from Cape Laurens.

To the southeast of the ship as she lay in the small bay at anchor was seen the succession of glaciers descending right down to the beach from this mountain, and separated by lateral moraines from one another; six of these glaciers were visible from the anchorage, forming by their terminations the coast line eastwards. They rose with a gentle slope with the usual rounded undulating surface, upwards towards the interior of the island, but their origin was hid in the mist and cloud.

One of them, that nearest to the ship, instead of abutting on the sea shore directly with its end as did the others, presented, towards its lower extremity, its side to the

[1] *Nautical Magazine*, vols. xxiii., xxiv., xxvii.; *Mercantile Magazine*, vols. v., xii.; *Petermann's Mittheilungen*, 1858; Personal Observations by Members of the Expedition.

SHEET 22


SOUNDINGS AND STATIONS
in the vicinity of
HEARD ISLAND
For explanation of abbreviations &c. see Appendix 1.
71°
72°
73°
74°
53°
72° Long. East from Greenwich
425
175
92
130
80
120
200
300
Meyers Rk.
(450 f.?)
Mc Donald I.
(650 f.?)
105 hard ground
HEARD I.d
Saddle Pt.
Mechanics B.
Morgan I.
West Bay
Fairchild beach
Spit Bay
Stealers Huts
C. Arcona
Long Beach
Corinthian Bay
Rogers Hd.
volcanic mud
Shag I.
Sail Rk.
Engraved by Malby & Sons.

action of the waves, and ending somewhat inland, formed a well-marked but scanty terminal moraine. To the sea shore this glacier presented a vertical wall of ice, resting directly upon the black volcanic sand composing the beach. In this wall was exposed a very instructive longitudinal section of the glacier mass, in which the series of curved bands produced by differential motion were most plainly marked, and visible from the distance of the anchorage. The ice composing the wall or cliff was evidently being constantly bulged outwards by internal pressure, and masses were thus being split off to fall on the beach, and be melted or floated off by the tide. The ice splits off along the lines of the longitudinal crevasses, and falls in slabs of the whole height of the cliff; a freshly fallen slab, a longitudinal slice of the glacier, was lying on the beach.

Some stones dredged in 150 fathoms between Kerguelen Island and Heard Island were believed to have been recently dropped by floating ice from Heard Island; they were not as yet penetrated by the water.

The other glaciers in sight cut the shore line at right angles, and thus had no terminal moraines, the stones brought down by them being washed away by the sea.

The glaciers showed all the familiar phenomena of those of Europe with exact similarity. There are here the same systems of crevasses, more marked in some regions than others, and dying out towards the termination of the glacier where the surface is smooth and generally rounded. The crevasses were of the usual deep blue colour, and the ridges separating them of the usual fantastic shapes. Above, the glaciers were covered with snow, which, as one looked higher and higher, was seen to gradually obliterate the crevasses, and assume the appearance of a névé. The extent of glacier free from snow was very small, the region in which thawing can take place to any considerable extent being confined to range not far above sea level. Here and there were to be seen on the surface of the glacier the usual deep vertical pipe-like holes full of water. These were lined by concentric layers of ice, composed of prisms disposed radially to the centres of the holes and produced by successive night frosts. Cones of ice covered with sand, and appearing as if composed of sand alone, but astonishing one by their hard and resistant nature when struck with a stick, were also to be seen on the glacier, just as on European glaciers; but here the sand was black and volcanic. Small table-stones were not uncommon upon the glacier, and in fact, all the phenomena caused by thawing from the action of direct radiant heat were present. The usual narrow longitudinal lines or cracks caused by the shearing of the ice in its differential motion were present, and gave evidence of the grinding together of the closely opposed surfaces forming them. The dirt and stones on the surface of the ice were as usual more abundant towards the termination of the glacier and the moraine, but they were not very numerous, and there were no large stones amongst them, nor were any to be seen in the moraine. The terminal moraine showed the usual irregular conical heaping, and also marks of

recent motion of the stones and earth composing it, due to the thawing of the ice supporting them; a small stream running from the glacier-bed cut its way to the sea through a short arched tunnel in the ice, as so commonly occurs elsewhere. A small cascade poured out of an aperture about half-way up the ice-cliff on to the sea shore. The lateral moraines were of the usual form, with sharp ridged crests and natural slopes on either side, and formed lines of separation between the contiguous glaciers. They were somewhat serpentine in course, and two of them were seen to occur immediately above points where the glaciers on either hand were separated by masses of rock *in situ*, which showed out between the ice-cliffs on the shore and had the ends of the moraines resting on them. All the moraines showed evidence of the present shrinking of the glaciers.

The view along the shore of the successive terminations of the glaciers was very fine, a coast line composed of cliffs and headlands of ice. None of the glaciers came actually down into the sea, the bases of their cliffs resting on the sandy beach, and only just washed by the waves at high water or during gales of wind.

Captain Nares, accompanied by Mr. Buchanan and Mr. Moseley, effected a landing on a smooth sandy beach bounding a sandy plain, being helped by six dirty-looking sealers who had made their appearance on the rocks, rifle in hand, as soon as the ship entered the bay, and had gazed on her with astonishment. The "boss" said, "I guess you are out of your reckoning," and they evidently thought no one could have come to Heard Island on purpose who was not in the sealing business.

The island here is very narrow, not more than a mile broad, and the sandy plain stretches from sea to sea; in fact, it forms the heads of three bays, namely, Corinthian Bay facing to the northeast, West Bay, and Atlas Cove. The connection of the two promontories with the main island by means of this sandy plain is so low that a depression of a few feet would suffice to separate them from each other and from the mainland. The sand is very dark-coloured and highly magnetic, and was being blown with such violence by the southwest wind then prevailing, that it was necessary, when exposed to it, to use some protection for the face. Nowhere can the abrading power of blown sand be better seen than on the isolated rocks which have rolled down from the heights above and remained fixed in the sandy plain, exposed to the constant strong southwesterly gales, driving the sharp volcanic sand against their sides. In this way they have frequently been cut and dressed as by a mason's chisel (see fig. 136). It is, however, not the southwesterly winds alone which produce this effect; but from their great predominance they have given the rocks the peculiar "sheared" appearance, much resembling that assumed by the trees growing on a coast exposed to the trade winds. If favourably placed rocks be carefully examined, the effect of every prevalent wind will be observed in the facets which it has produced on the surface. The largest facet, and the one which determines the general appearance of the rock, is the one turned towards

the west; and the areas of the others would doubtless afford useful information as to the relative prevalence of other winds.

The sandy plain stretches back from the bay as a dreary waste to a small curved beach at the head of another inlet of the sea. Behind this inlet is an irregular rocky mountain mass forming the end of the island, on which are two large glaciers very steeply inclined, one of them terminating in a sheer ice-fall. At its back this mountain mass is bounded by precipices with their bases washed by the sea.

The plain is traversed by several streams of glacier water coming from the southern glaciers. These streams are constantly changing their course, as the beach and plain are partly washed about by the surf in heavy weather. At the time of the visit the main stream stretched across the entire width of the plain and entered the sea at the extreme

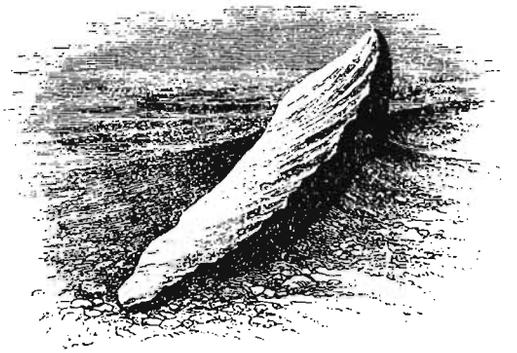


FIG. 136, from a sketch by Mr. Buchanan, represents a rock embedded in the black sand. The side towards the west, with the high light on the woodcut, is being rapidly worn down by the sharp sand blown against it, which has cut an irregularly fluted pattern in it.

western verge of the beach; it was about 20 yards across, knee-deep, and had therefore to be forded. The water was intensely cold, brown, opaque, and muddy, charged with the grindings of the glaciers. Running into the sea it formed a conspicuous brown tract, sharply defined from the blue-green sea water, and extending almost to the mouth of the bay.

The sandy plain seemed entirely of glacial origin, and was in places covered with yielding glacial mud, very heavy to walk upon. It was strewn with bones of the Elephant Seal and the Sea Leopard (*Stenorhynchus leptonyx ?*), those of the former being most abundant. There were remains of thousands of skeletons, and a good many tusks of old males were gathered. The bones lay in curves looking like tide lines on either side of the plain above the beaches, marking the rookeries of old times and the tracks of slaughter of the sealers.

On the opposite side of the plain from that bounded by the glacier is a stretch of low bare rock with a peculiar smooth and rounded but irregular surface. This rock surface appears from a distance as if glaciated, but on closer examination it is seen to show very

distinct ripple marks and lines of flow, and the rock mass is evidently a comparatively recent lava flow from a small broken-down crater which stands on the shore close by. The remains of the crater are now in the form of three fantastic irregularly conical masses, composed of very numerous thin layers of scoriæ, conspicuous because of their varied and strongly contrasted colours and very irregular bedding. The lava flow is seen in section in the low cliffs forming the coast line of the harbour.

The rocks collected at Heard Island have been referred to augite-andesite, felspathic basalt, and tufa, composed of basaltic fragments and minerals. Some specimens are transitional between basalt and augite-andesite.

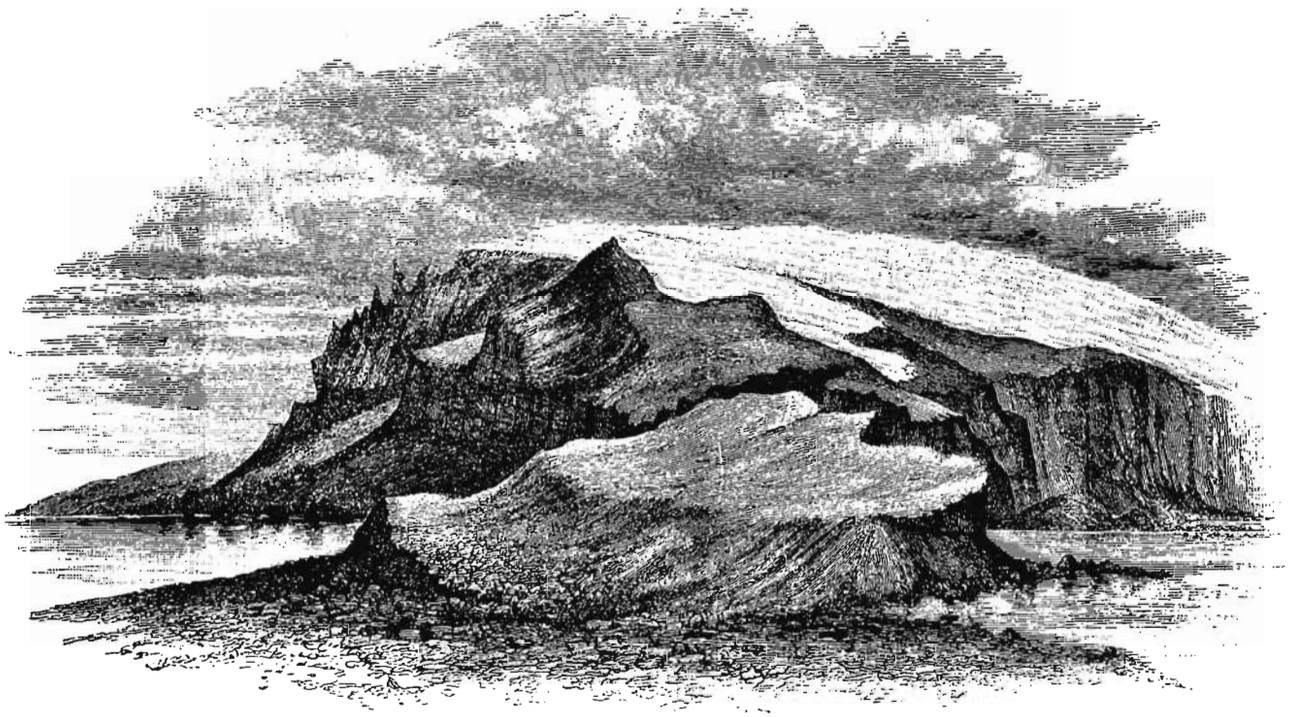


FIG. 137, from a sketch by Mr Buchanan, represents the mountainous promontory forming the northwestern end of the island. The top of the mountain was enveloped in cloud, below which the greater part of its sides were covered by a glacier descending to the edge of the precipitous rock cliffs over which the ice masses fell thundering. The sketch was taken from the shoulder of a red conical hill against which the ice, descending from the main mountain of the island to the sea, splits and passes on both sides of it.

The present condition of Heard Island is evidently that which obtained in Kerguelen Island formerly. Glaciers once covered Kerguelen Island almost entirely and dipped down into the sea. It is, however, an extraordinary fact that Heard Island, only 300 miles south of Kerguelen Island, should thus still be in a glacial period, whilst in Kerguelen Island, a very much larger tract, the glaciers should have shrunk back into the interior, and have left so much of the land surface entirely free from ice, the ice epoch being there already a thing of the past. The great height of Big Ben, and consequent

largeness of the area where snow constantly accumulates and cannot be melted, no doubt accounts to a considerable extent for the peculiar conditions in Heard Island. A similar rapid descent of the snow-line within a few degrees of latitude occurs in the Chilian Andes,[1] so great is the cooling influence of the vast Southern Ocean. Heard Island is in a corresponding latitude to Lincoln; possibly when England was in its last glacial epoch Heard Island enjoyed a much milder climate, and it was probably then that the large trees grew, the trunks of which are now fossil in Kerguelen Island, and that the ancestors of *Lyallia* and *Pringlea* flourished.

A stretch of land on the northwest side of the plain was covered pretty thickly with green, which on closer examination was seen to be composed of patches of *Azorella* growing on the summits of mud or sand hummocks, separated from one another by ditches or cavities, of usually bare brown mud. Some of these *Azorella* patches were of considerable extent, and the plant was evidently flourishing and in full fruit. On some hummocks grew tufts of the grass, *Poa cookii*, in full flower and with the anthers fully developed; and on the sheltered banks the Kerguelen Cabbage (*Pringlea antiscorbutica*) grew in considerable quantity, but dwarfed in comparison with Kerguelen specimens, both in foliage and in the length of the fruiting stems. Most of it was in fruit, but some still in flower, as at Kerguelen Island. Around pools of water in the hollows grew a variety of a British plant, *Callitriche verna* (var. *obtusangula*), in quantity, and it occurred also in abundance submerged, in company with a Conferva. In the same sheltered spots grew *Colobanthus kerguelensis*, in greater abundance even than at Kerguelen Island. These five flowering plants,[2] all occurring also in Kerguelen Island, were the only ones found in the island, and it is improbable that any others grow there. Heard Island has thus a miserably poor flora, even for the higher latitudes of the southern hemisphere. The Falkland Islands, in lat. 51° to 52° S., have one hundred and nineteen phanerogamic plants, and Hermit Island, far to the south of Heard Island, in lat. 56° S., has eighty-four phanerogams, and amongst them trees which there reach their southern limit.

About the sides of the hummocks already described grew scantily four species of Mosses, one of which (*Grimmia* [*Schistidium*] *insularis*, Mitt.) proved to be new and peculiar to the island. The greater part of the land surface of Heard Island free from ice, besides the green tract described, is entirely devoid of vegetation. Only on the talus slopes of the hills on their sheltered sides, are seen scattered in a very few places scanty patches of green. These, composed mainly of *Azorella*, stretching up the slopes, terminate at an elevation of a few hundred feet in bright yellow patches, which are composed of Mosses just as at Marion Island on the high slopes. Lichens were searched for in vain.

At Corinthian Bay large masses of seaweeds were banked up on the sandy shore;

[1] Grisebach, Die Vegetation der Erde, Bd. ii. p. 467, Leipzig, 1872; Darwin, Journal of Researches during the Voyage of H.M.S. "Beagle," p. 244, ed. 1879.

[2] Professor Oliver, F.R.S., *Journ. Linn. Soc. Lond.*, vol. xiv. p. 389, 1875.

eight species were collected which have been described by Professor Dickie.[1] Amongst them were two new ones, and three which occur at Kerguelen Island, whilst the remainder occur in Patagonia and Chili. The main mass appeared considerably different from the masses of Algæ found on the Kerguelen shore. *Durvillea utilis* grew attached to the rocks under the cliffs, but the Kelp (*Macrocystis pyrifera*) does not grow at all about this group of islands according to the sealers, which is a remarkable fact, when its great abundance at Kerguelen's Land is kept in mind.

The only insects seen at the island were the large apterous Fly of Kerguelen Island (*Calycopteryx moseleyi*), which shelters itself, as there, in the heart of the Kerguelen Cabbage, and a single dead specimen of a small beetle, found amongst the *Azorella*, which was unfortunately lost.

The water is deep all round Heard Island, except off the southeast point, where a bank of black mud and sand is said to extend to a great distance; off the coast are a few detached rocks and islands. Red Island, off the north point, is a small dome-shaped mass of dark red lava, about 200 feet high, separated from the coast by a channel, half a mile in width, which did not appear navigable. One and a half miles north of Red Island the depth is 60 fathoms, the bottom being shelly. In Corinthian Bay is a black steeple rock, about 30 feet high, which has been named Church Rock, standing in front of a whitish blue glacier. Four miles east of Saddle Point, the eastern end of Corinthian Bay, are three small dark islands, named "Morgan Islands." Seven and a half miles northeast of Rogers' Head are three small islets, named "Shag Islands," the highest of which is about 200 feet high; a mile west of them the depth is 75 fathoms. The central Shag Island is in lat. 52° 59′ 30″ S., long. 73° 35′ 30″ E.

Shortly after its discovery, viz., in March 1855, Heard Island was visited by Captain Rogers of the American whaler "Corinthian" and his four tenders, the "Atlas," "Mechanic," "Exile," and "Franklin." They anchored in Corinthian Bay, and reaped a rich harvest of Elephant Seals, procuring in one day four or five hundred barrels of oil. The names of the ships composing Captain Rogers' squadron were given to the various conspicuous headlands, bays, and islets of the group, and still serve to record the visit of the seamen who first landed there.

Since 1855 an Elephant Seal fishery has been regularly established at Heard Island, but, owing to the want of a well-sheltered anchorage, it has been found necessary to land a party for the purpose. At the time of the Challenger's visit there were forty men on the island, distributed in parties along the coast, the largest number at the south end. At Corinthian Bay there were only six men, who were living in huts sunk in the ground, partly to protect them against the strong westerly winds, which blow through the gap separating the mountain in the northwest promontory from the main mountain, with much violence, and partly for warmth, as in winter they cover them with snow.

[1] *Journ. Linn. Soc. Lond.*, vol. xv. p. 47, 1876; Bot. Chall. Exp., part ii. p. 256, 1884.

They appeared to have a good stock of food and supplies of all kinds, the ground in the vicinity of their huts being strewn with casks, tanks, sledges, hand-carts, and old pots, and they vary their diet of salt beef, &c., with Penguins, which they look on as excellent food; for fuel they use the skin and fat of the Penguin.

The men stationed at the different points of the island have considerable difficulty in keeping up communication with each other, and in transporting their blubber to such parts of the coast as are accessible to the sealing schooners. If they walk along the beach they occasionally have to go under the overhanging ledges of ice from the glacier, which may break off at any time and annihilate them; in fact, one boat's crew was lost in this way on the south side of Corinthian Bay, and in travelling over the glacier the numerous crevasses obstruct their progress considerably. It is requisite also for them to endeavour to get the Elephant Seals to land on those beaches which can be most readily communicated with, for it is no use their killing the animals and collecting their blubber unless they can transport it to the place of shipment, so they have to watch the coast constantly and try to beat off the Elephant Seals from the least accessible parts in order to get them to land on beaches favourable for transport. The blubber collected at Long Beach is transported over the ice to Spit Bay.

The Elephant Seals are reported to be nearly as plentiful as ever, and the whalers reason that other islands must therefore exist hereabouts where they keep up the breed, but one would think that had they any other place of resort they would abandon this island, so much are they harassed; in fact, they are now only to be found on the weather shore, as they seldom attempt to land on the lee side. Their favourite breeding place is Long Beach, on the southwest coast. The males land first, and the females some few days after. The male Elephant Seals, like the males of other Seals, constantly quarrel and fight with each other, the largest full-grown animals beating the smaller, and driving them into the sea; these large fighting males are called by the sealers "Beach Masters."

The sealing settlements are visited annually by the barque "Roman" and her two tenders, the schooners "Roswell King" and "Emma Jane." They generally arrive in Corinthian Bay in October, and, naturally, their coming is looked forward to by the men on shore as the great event of the year; much rejoicing takes place when they meet their comrades, and a considerable consumption of whisky follows, so that this rendezvous is as frequently called "Whisky" as "Corinthian" Bay. The schooners anchor in Mechanic's Bay, Morgan Bay, and Spit Bay, to collect the blubber, which is rafted off to them, and remain at the island until about the end of December; but this work is extremely hazardous as east winds are by no means uncommon, and the island, lying in a northwest and southeast direction, does not afford any very great protection against the prevailing westerly swell.

The weather in the vicinity of Heard Island is foggy and boisterous, and, although the prevailing wind is westerly, gales from the northward and eastward are not at all

uncommon. As a rule the westerly winds bring moderately clear weather, the easterly much fog and mist. December is the finest month, and at this season of the year a fortnight's really fine weather may be sometimes experienced, but it cannot be depended on. In the winter the whole island is snow-clad, and the sealers at the settlement have to melt snow or ice to obtain water; in the summer the lower lands, protected by elevations from the descending glacier, are free from snow, but at all seasons a fall may take place at any moment. The icebergs occasionally seen in the neighbourhood are not generated by the glaciers from either Kerguelen or Heard Islands, for the sea water in the vicinity is too warm to permit the base of the glacier to remain undissolved, and consequently only small pieces of ice, comparatively speaking, can be derived from this source.

Landing at Heard Island is always difficult and frequently impracticable. Only the one boat's party above referred to landed during the Challenger's stay, the weather having become unfavourable immediately afterwards.

With reference to the direction of the wind and state of the weather, it may perhaps be as well to draw attention here to the fact that easterly winds seldom if ever blow at Kerguelen Island, but 100 miles south of it and in the neighbourhood of Heard Island they are quite common. It would appear, therefore, unadvisable for sailing vessels running down their easting to adopt a route south of Kerguelen, even supposing the chances of meeting icebergs were equal on both sides of that island, but considering the much less danger of meeting those obstructions to navigation on the northern side, there can hardly be a doubt as to which is the preferable route.

On the 7th February shortly after midnight the barometer began to fall rapidly, the wind became light, and snow fell all the middle watch. At 4 A.M. the wind shifted to the southeast, a slight swell came into Corinthian Bay, and the weather being thick and misty it was considered unadvisable to remain longer at anchor in such an exposed position, so steam having been got up the anchor was weighed at 5 A.M. and the ship proceeded towards Shag Island to ascertain its position by a patent log distance from Rogers' Head. At 7 A.M. the vessel stopped off Shag Island, being then within half a mile of it, but the weather was so thick that its outline could only just be discerned through the mist. There being little wind, a sounding and dredging were obtained here in 75 fathoms.

At 9 A.M. the ship steamed towards Red Island, which was rounded at 10.30 A.M., obtaining no bottom with 45 fathoms. The course was then altered gradually to the southward, the weather remaining thick, so that the land could not be distinguished at any distance. At noon a breeze sprang up from the northwest and sail was made to the southward, the fires being banked. At 12.15 P.M. the land was completely obscured, although the ship was but $2\frac{1}{2}$ miles from the coast, and nothing more was seen of it. The wind freshened quickly to a gale, so that it was necessary to reef the topsails and courses, and at 11 A.M. the ship "laid to" under triple-reefed topsails; it was then

blowing a hard westerly gale, and it was a matter of congratulation that the ship had left the insecure anchorage of Corinthian Bay.

The necessity for leaving Heard Island without thoroughly exploring it was a source of much regret. Had it remained fine for a few days, a survey might have been completed which would have been all that was requisite for passing vessels, but the unfavourable state of the weather prevented anything more being done than fixing the position of its northern end, the remainder of the island being depicted from a sketch-map made by the American sealing captains. The glaciers and peculiar formation of the land, also, are well worthy of investigation, more especially the sickle-shaped spit running to the northward from its southeast extremity, from which shoal water is said to extend. The report of this shoal water prevented the Expedition passing down the east side of the island, for it would have been dangerous for the ship to have become entangled amongst shoals in the thick weather experienced, even had the wind been moderate.

The deposit in 75 fathoms off Shag Island was a blackish green volcanic mud, composed essentially of black volcanic sand and remains of organisms. There was apparently not more than 1 or 2 per cent. of carbonate of lime, consisting of *Miliola*, *Discorbina*, *Uvigerina*, and one or two *Globigerina* shells, along with fragments of Polyzoa, Molluscs, Echinoderms, &c. The mineral particles had a mean diameter of about 0·6 mm., and formed a black sand consisting chiefly of fragments of brown and red glass—sometimes decomposed, sometimes massive and enclosing microliths of olivine, and sometimes porous—with fragments of felspar, plagioclase, augite, and magnetite. There were also very many Diatoms and Sponge spicules in the mud.

The dredge brought up many specimens of Sponges, Alcyonarians, Holothurians, Ophiurids, *Euryale*, Asterids, *Brisinga*, Echinids, Annelids, Amphipods, Polyzoa, Gasteropods, Cephalopods, and many other invertebrates resembling closely those obtained in the dredgings around Kerguelen.

Among the Echinoderms dredged at this Station was *Psolus ephippifer* described by the late Sir Wyville Thomson in the following interesting notes on the reproduction of certain Echinoderms from the Southern Ocean :—" Adhering to the fronds of *Macrocystis* there were great numbers of an elegant little cucumber-shaped Sea-slug (*Cladodactyla crocea*, Lesson, sp.) from 80 to 100 mm. in length by 30 mm. in width at the widest part, and of a bright saffron-yellow colour. The mouth and excretory opening are terminal ; ten long, delicate, branched oral tentacles, more resembling in form and attitude those of *Ocnus* than those of the typical Cucumariæ, surround the mouth; the perisome is thin and semitransparent, and the muscular bands, the radial vessels, and even the internal viscera can be plainly seen through it. The three anterior ambulacral vessels are approximated, and on these the tentacular feet are numerous and well developed, with a sucking-disk supported by a round cribriform calcareous plate, or more frequently

by several wedge-shaped radiating plates arranged in the form of a rosette; and these three ambulacra form together, at all events in the female, a special ambulatory surface.

"The two ambulacral vessels of the 'bivium' are also approximated along the back, and thus the two interambulacral spaces on the sides of the animal, between the external trivial ambulacra and the ambulacra of the bivium, are considerably wider than the other three; consequently, in a transverse section, the ambulacral vessels do not correspond with the angles of a regular pentagon, but with those of an irregular figure in which three angles are approximated beneath and two above. In the female the tentacular feet of the dorsal (bivial) ambulacra are very short; they are provided with sucking-disks, but the calcareous support of the suckers is very rudimentary, and the tubular processes are not apparently fitted for locomotion. In the males there is not so great a difference in character between the ambulacra of the trivium and those of the bivium; but the tentacles of the latter seem to be less fully developed in both sexes, and I have never happened to see an individual of either sex progressing upon, or adhering by, the water-feet of the dorsal canals.

"In a very large proportion of the females which I examined, young were closely packed in two continuous fringes adhering to the water-feet of the dorsal ambulacra (fig. 138). The young were in all the later stages of growth, and of all sizes from 5 up to 40 mm. in length; but all the young attached to one female appeared to be nearly of the same age and size. Some of the mothers with older families had a most grotesque appearance—their bodies entirely hidden by the couple of rows, of a dozen or so each, of yellow vesicles like ripe yellow plums ranged along their backs, each surmounted by its expanded crown of oral tentacles; in the figure the young are represented about half-grown. All the young I examined were miniatures of their parents; the only marked difference being that in the young the ambulacra of the bivium were quite rudimentary—they were externally represented only by bands of a somewhat darker orange than the rest of the surface, and by lines of low papillæ in the young of larger growth; the radial vessels could be well seen through the transparent body-wall; the young attached themselves by the tentacular feet of the trivial ambulacra, which are early and fully developed.

"We were too late at the Falklands (January 23rd) to see the process of the attachment of the young in their nursery, even if we could have arranged to keep specimens alive under observation. There can be little doubt that, according to the analogy of the class, the eggs are impregnated either in the ovarial tube or immediately after their extrusion, that the first developmental stages are run through rapidly, and that the young are passed back from the ovarial opening, which is at the side of the mouth, along the dorsal ambulacra, and arranged in their places by the automatic action of the ambulacral tentacles themselves.

"The very remarkable mode of reproduction of certain members of all the recent

classes of Echinodermata by the intervention of a free-swimming bilaterally symmetrical 'pseudembryo' developed directly from the 'morula,' from which the true young is subsequently produced by a process of internal budding or rearrangement, has long been well known through the labours of a host of observers, headed and represented by the late illustrious Professor Johannes Müller of Berlin.

"At the same time it has all along been fully recognised that reproduction through

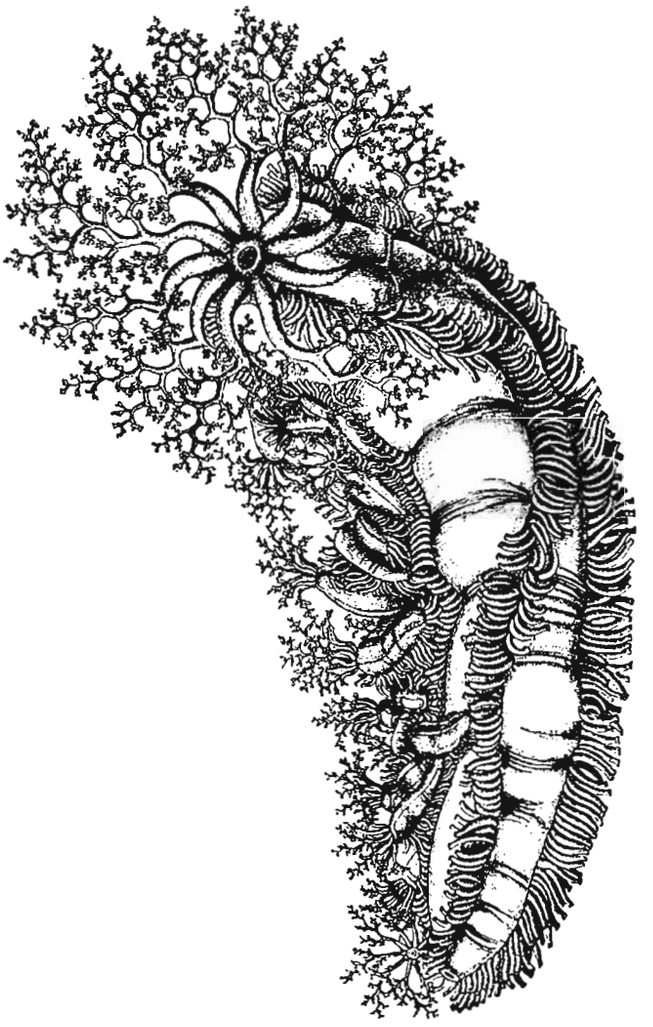


FIG. 138.—*Cladodactyla crocea* (Lesson). Stanley Harbour, Falkland Islands. Natural size.

the medium of a 'pseudembryo' is not the only method observed in the class, but that in several of the Echinoderm orders, while in a certain species a wonderfully perfect and independent bilateral locomotive zooid may be produced, in very nearly allied species the young Echinoderm may be developed immediately from the segmented yelk without the formation of a 'pseudembryo,' or at all events with no further indication of its presence

than certain obscure temporary processes attached to the embryo, to which I have elsewhere given the name of 'pseudembryonic appendages.'[1]

"This direct mode of development has been described in *Holothuria tremula* by MM. Koren and Danielssen, in *Synaptula vivipara* by Professor Oersted, in a 'viviparous sea-urchin' by Professor Grube, in *Echinaster* and in *Pteraster* by Professor Sars, in *Asteracanthion* by Professor Sars, Professor Agassiz, Dr. Busch, and by myself, in *Ophiolepis squamata* by Professor Max Schultze, and in 'a viviparous Ophiurid' by Professor Krohn. No less than four of these observations were made on the coast of Scandinavia. In temperate regions, where the economy of the Echinoderms has been under the eye of a greater number of observers, the development of the free-swimming larva appeared to be so entirely the rule that it is usually described as the normal habit of the class; while on the other hand, direct development seemed to be most exceptional. I was therefore greatly surprised to find that in the Southern Ocean and sub-antarctic regions a large proportion of the Echinoderms of all orders, with the exception perhaps of the Crinoids (with regard to which we have no observations), develop their young after a fashion which precludes the possibility, while it nullifies the object, of a pseudembryonic perambulator, and that in these high southern latitudes the formation of such a locomotive zooid is apparently the exception.

"This modification of the reproductive process consists in all these cases, as it does likewise in those few instances in which direct development has already been described, of a device by which the young are reared within or upon the body of the parent, and are retained in a kind of commensal connection with her until they are sufficiently grown to fend for themselves. The receptacle, in cases where a special receptacle exists in which the young are reared, has been called a 'marsupium' (Sars), a term appropriately borrowed from the analogous arrangement in their neighbours the aplacental mammals of Australia. The young do not appear to have in any case an organic connection with the parent; the impregnated egg from the time of its reaching the 'morula' stage is entirely free; the embryos are indebted to the mother for protection, and for nutrition only indirectly through the mucus exuded from the surface of her perisome, and through the currents of freshly aerated water containing organic matter brought to them or driven over them by the action of her cilia.

"Animals hatching their eggs in this way ought certainly to give the best possible opportunities for studying the early stages in the development of their young. Unfortunately, however, this is a kind of investigation which requires time and stillness and passable comfort; and such are not the usual conditions of a voyage in the Antarctic Ocean. Specimens have been carefully preserved with the young in all stages; and I hope that a careful examination of these may yield some further results.

"*Cladodactyla crocea* is one of the forms in which there is no special marsupium

[1] *Phil. Trans.*, p. 517, 1865.

formed; it is possible that the comparatively genial condition of the land-locked fjords and harbours of the Malvinas, and the additional shelter yielded by the imbricating fronds of *Macrocystis*, may render such exceptional provision unnecessary.

"Five at least of these directly developing Echinoderms representing five principal divisions of the sub-kingdom, were dredged at the Falklands, and several others were found earlier in the voyage in the sub-antarctic regions of the Southern Ocean. It will perhaps give a better idea of the diversity of means by which practically the same end is attained, if I give here a brief description of the principal modifications of the process which were exhibited.

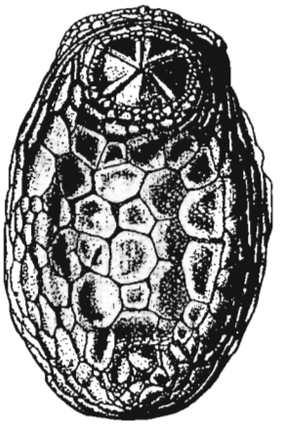


FIG. 139.—*Psolus ephippifer*, Wyv. Thoms. Corinthian. Harbour, Heard Island. Three times the natural size.

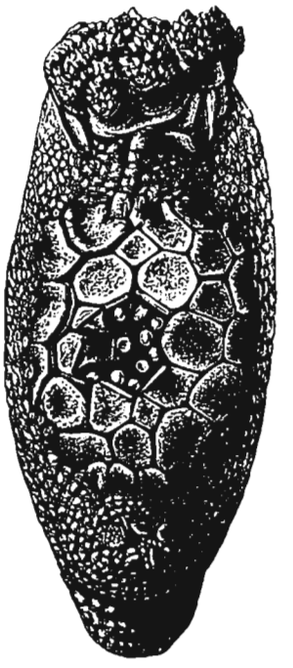


FIG. 140.—*Psolus ephippifer*, Wyv. Thoms., some of the plates of the marsupium removed. Three times the natural size.

"To give a second example from the Holothurioidea, on the morning of the 7th of February 1874, we dredged at a depth of 75 fathoms, at the entrance of Corinthian Harbour (*alias* 'Whisky Bay') in Heard Island (so far as I am aware the most desolate spot on God's earth), a number of specimens of a pretty little *Psolus*, which I shall here call, for the sake of convenience, *Psolus ephippifer*, although it may very possibly turn out to be a variety of the northern *Psolus operculatus*.

"*Psolus ephippifer* (figs. 134, 135) is a small species, about 40 mm. in length by 15 to 18 mm. in extreme width. In accordance with the characters of the genus, the ambulatory area is abruptly defined, and tentacular feet are absent on the upper surface of the body, which is covered with a thick leathery membrane in which calcareous scales

of irregular form are imbedded. The oral and excretory openings are on the upper surface, a little behind the anterior border of the ambulatory tract, and a little in advance of the posterior extremity of the body respectively. A slightly elevated pyramid of five very accurately fitting calcareous valves closes over the oral aperture and the ring of oral tentacles, and a less regular valvular arrangement covers the vent.

"In the middle of the back in the female there is a well-defined saddle-like elevation formed of large tessellated plates somewhat irregular in form, with the surfaces smoothly granulated (fig. 139). On removing one or two of the central plates we find that they are not, like the other plates of the perisome, imbedded partially or almost completely in the skin, but that they are raised up on a central column like a mushroom or a card-table, expanding above to the form of the exposed portion of the plate, contracting to a stem or neck, and then expanding again into an irregular foot, which is imbedded in the soft tissue of the perisome; the consequence of this arrangement is that when the plates are fitted together edge to edge, cloister-like spaces are left between their supporting columns. In these spaces the eggs are hatched, and the eggs or the young in their early stages are exposed by removing the plates (fig. 140). At first, when there are only morules or very young embryos in the crypts, the marsupium is barely raised above the general surface of the perisome, and the plates of the marsupium fit accurately to one another (fig. 139); but as the embryos increase in size, the marsupium projects more and more, and at length the joints between the plates begin to open, and finally they open sufficiently to allow the escape of the young. The young in one marsupium seem to be all nearly of an age. In *Psolus ephippifer* the marsupium occupies the greater part of the dorsal surface, and its passages run close up to the edge of the mouth, so that the eggs pass into them at once from the ovarial opening without exposure.

"In the male there is, of course, no regular marsupium; but the plates are arranged in the middle of the back somewhat as they are in the female, except that they are not raised upon peduncles; so that it is not easy at once to distinguish a male from an infecund female.

"Although we have taken species of *Psolus* sometimes in great abundance in various parts of the world, particularly in high latitudes, southern and northern, I have never observed this peculiar modification of the reproductive process except on this one occasion.

"On the 28th of January 1876 we dredged from the steam pinnace in about 10 fathoms water off Cape Pembroke, at the entrance of Stanley Harbour, Falkland Islands, a number of specimens of a pretty little regular sea-urchin, *Goniocidaris canaliculata*, A. Agassiz.

"The genus *Goniocidaris* (Desor) seems to differ from the genus *Cidaris* in little else than in having a very marked, naked, zigzag, vertical groove between the two rows of plates of each interambulacral area, and one somewhat less distinct between the ranges of ambulacral plates. It includes about half a dozen species, which appear to be mainly

confined to the colder regions of the southern hemisphere, although two of the species extend as far to the northward as the East Indies and Natal.

"This species (fig. 141) has a general resemblance at a first glance to the small Mediterranean variety (*affinis*) of *Cidaris papillata*,[1] but the radioles are thinner and much shorter, and differ wholly in their sculpture; the shell is even more depressed; the secondary tubercles are more distant; and a very regular series of short club-shaped rays seated on miliary granules are interposed in the rows between the spines of the second order. The ovarial openings are extremely minute, and are placed close to the outer edge of the ovarial plates. The upper part of the test is quite flat, the flat space including not only the ovarial plates and the plates of the periproct, but the first pair, at least, of the plates of each interambulacral area. Articulated to the primary tubercles of these

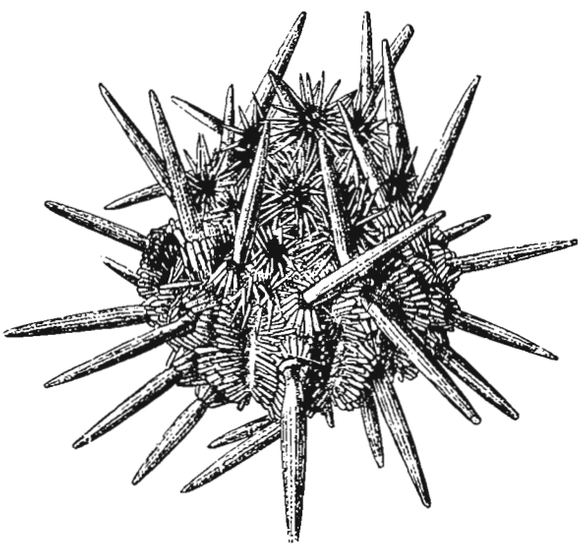


FIG. 141.—*Goniocidaris canaliculata*, A. Agassiz. Stanley Harbour, Falkland Islands. Twice the natural size.

latter are two circles of radioles, the inner more slender and shorter, the outer stouter and longer, but both series much larger than radioles usually are in that position on the test.

"These special spines are cylindrical, and nearly smooth, and they lean over towards the anal opening, and form an open tent for the protection of the young, as in *Cidaris nutrix*, a species presently to be described, but at the opposite pole of the body. In this species the eggs are extruded directly into the marsupium; and I imagine, from the very small size of the ovarial openings, that when they enter it, they are very minute, and probably unimpregnated. In the examples which we dredged at the Falkland Islands, the young were, in almost every case, nearly ready to leave the marsupium; we were too late in the season to see the earlier stages, young in the same marsupium are nearly all of an age, some somewhat more advanced than others. The diameter of the test is from 1 to 1·5 mm., and the height about 0·8 mm.; the length of the primary spines

[1] *Dorocidaris papillata* of A. Agassiz.

is, in the most backward of the brood, 0·5 mm., while in the most advanced it equals the diameter of the test. The perisome, in which the cribriform rudiments of the plates of the corona and the young spines are being developed, is loaded with dark purple pigment, which makes it difficult to observe the growth of the calcareous elements. About thirty primary spines arise on the surface of the corona almost simultaneously in ten rows of three each: they first make their appearance as small papillæ covered with a densely pigmented ciliated membrane; and when they have once begun to lengthen, they run out very rapidly until they bear to the young nearly the same proportions which the full-grown spines bear to the mature corona. Very shortly some of the secondary spines, at first nearly as large as the sprouting primary spines, make their appearance in the interstices between these; and a crowd of very small spines rises on the nascent scales of the peristome. Successively five or six pedicellariæ are developed towards the outer edge of the apical area, which at this stage is disproportionately large; the pedicellariæ commence as purple papillæ, which are at first undistinguishable from young primary spines; the first set look enormously large in proportion to the other appendages of the perisome. Almost simultaneously with the first appearance of the primary spines, ten tentacular feet, apparently the first pairs on each ambulacrum of the corona, just beyond the edge of the peristome, come into play; they are very delicate and extremely extensile, with well-defined sucking-disks; and with these the young cling to and move over the spines of the mother, and cling to the sides of the glass vessel, if they are dislodged from the marsupium. This species seems to acquire its full size during a single season. We dredged it at the close of the breeding season, and took no specimens intermediate in size between the adult and the young.

"Among the marine animals which we dredged from the steam pinnace on the 19th of January 1874, at depths of from 50 to 70 fathoms in Balfour Bay (a fine recess of one of the many channels which separate the forelands and islands at the head of Royal Sound, Kerguelen Island), there were several examples of a small *Cidaris*, which I will name provisionally *Cidaris nutrix*[1] (fig. 142).

"This species resembles *Cidaris papillata* in the general form and arrangement of the plates of the corona, in the form and arrangement of the primary tubercles of the interambulacral areas and of the secondary tubercles over the general surface of the test, in the form of the plates of the apical disk and of the imbricated calcareous scales of the peristome, in the form, sculpture, and proportionate length of the primary spines, and in the form of the different elements of the jaw-pyramid and in that of the teeth; but the test is more depressed, the secondary spines which articulate to the ambulacral plates and cover the pore-areas are longer and more cylindrical, not so much flattened as they are in *Cidaris papillata*; the large tulip-like pedicellariæ and the long thin tridactyle pedicellariæ mixed with the secondary spines in the northern species are wanting, or in very

[1] Described by Alex. Agassiz as a variety of *Goniocidaris canaliculata*, Zool. Chall. Exp., part ix., p. 44, 1881.

small number; and the minute pedicellariæ of the peristome are much fewer. The ovaries, which in *Cidaris papillata* have the walls loaded with large expanded calcareous plates, contain only a few small branched spicules; and the calcareous bodies in the wall of the intestine are small and distant. The perforations in the ovarial plates in the female are somewhat larger than in *Cidaris papillata;* and the ripe ova in the ovary appear to be considerably larger.

"The eggs, after escaping from the ovary, are passed along on the surface of the test towards the mouth; and the smaller slightly spatulate primary spines which are articulated to about the first three rows of tubercles round the peristome, are bent inwards over

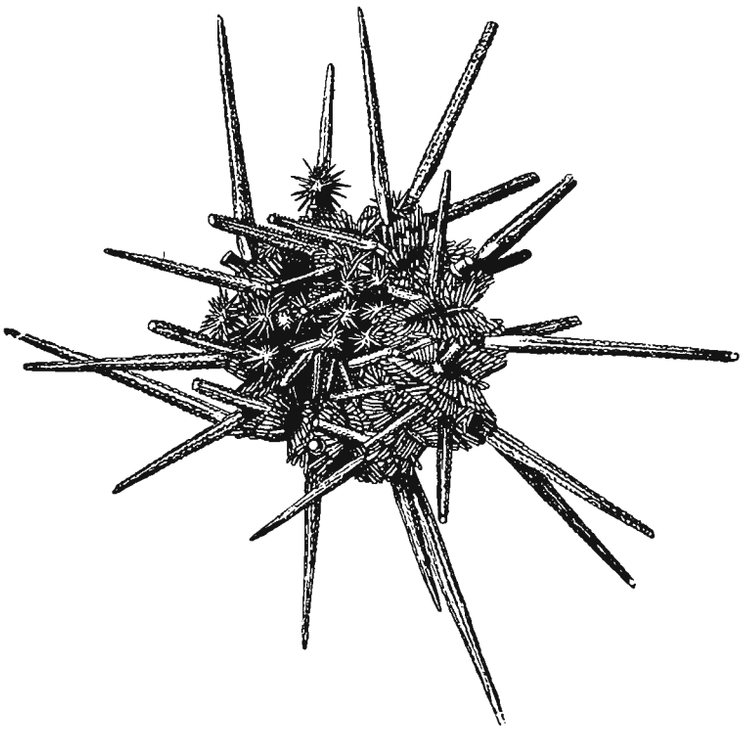


FIG. 142.—*Goniocidaris canaliculata* (*Cidaris nutrix*, Wyv. Thoms.). Balfour Bay, Kerguelen Island. Natural size.

the mouth, so as to form a kind of open tent, in which the young are developed directly from the egg without undergoing any metamorphosis, until they have attained a diameter of about 2·5 mm.; they are then entirely covered with plates, and are provided with spines exceeding in length the diameter of the test. Even before they have attained this size and development, the more mature or more active of a brood may be seen straying away beyond the limits of the 'nursery,' and creeping with the aid of their first few pairs of tentacular feet out upon the long spines of their mother; I have frequently watched them return again after a short ramble into the 'marsupium.'

"I am not aware that a free pseudembryo, or 'pluteus,' has been observed in any species of the restricted family Cidaridæ; but I feel very certain that *Cidaris papillata*

in the northern hemisphere, except possibly in the extreme north, has no marsupial arrangement such as we find in the Kerguelen *Cidaris*. There have passed through my hands during the last few years hundreds of specimens of the normal northern form, of the Mediterranean varieties *Cidaris hystrix* and *Cidaris affinis* (*stokesii*), and of the American *Cidaris abyssicola*,[1] from widespread localities and of all ages; and I have never found the young except singly, and never in any way specially associated with breeding individuals.

"In Stanley Harbour we dredged many specimens of an irregular urchin, much resembling in general appearance *Brissopsis lyrifera*, the common 'fiddle urchin' of the boreal province of the British seas, and probably to be referred to *Hemiaster philippii*, Gray.[2]

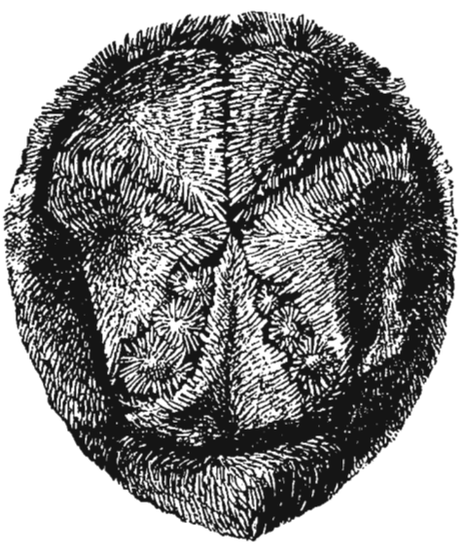


FIG. 143.—*Hemiaster cavernosus* (Phil.). Accessible Bay, Kerguelen Island. Twice the natural size.

"These urchins were not breeding when we were at the Falklands, but on the 9th of January 1874 we dredged from the pinnace in shallow water, varying from 20 to 50 fathoms, with a muddy bottom, in Accessible Bay, Kerguelen Island, innumerable samples of apparently the same species.

"The test of a full-sized example (fig. 143) is about 45 mm. in length and 40 mm. in width; the height of the shell in the female is 25 mm., in the male it is considerably less. The apex is nearly in the centre of the dorsal surface; the genital openings are three in number, in the female very large; the bilabiate mouth is placed well forward on the ventral aspect; and the excretory opening is posterior and supramarginal. The odd anterior ambulacrum is shallow, and the tube-feet which are projected from it are large and capitate. The anterior paired ambulacra are somewhat longer than the posterior. The whole of the surface of the test is covered with a close pile of small spines of a dark green colour; those fringing the ambulacral grooves are long and slightly curved, and they bend and interdigitate so accurately over the ambulacra that one might easily overlook the grooves at a first glance. The peripetalous fasciole is somewhat irregular; but in those examples in which it is best defined it forms a wide arch, extending backwards on each side a little beyond the lateral ambulacra of the trivium, and then, contracting a little, forms a rudely rectangular figure round the bivium. The paired ambulacral grooves in the male are shallow, not much deeper than the anterior ambulacrum (fig. 145); in the female the pore-plates of the paired ambulacra are greatly expanded and

[1] These are regarded by Alex. Agassiz as varieties or developmental stages of *Dorocidaris papillata;* see Zool. Chall. Exp. part ix. p. 44, &c., 1881.

[2] Described by Alex. Agassiz as *Hemiaster cavernosus* (Philippi), *loc. cit.*, p. 177.

lengthened, and thinned out and depressed so as to form four deep, thin-walled, oval cups sinking into and encroaching upon the cavity of the test, and forming very efficient protective 'marsupia' (fig. 144). The ovarial openings are, of course, opposite the inter-

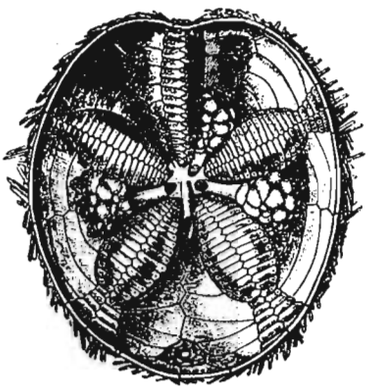


FIG. 144.—*Hemiaster cavernosus* (Phil.). The apical portion of the test of the female seen from within. Slightly enlarged.

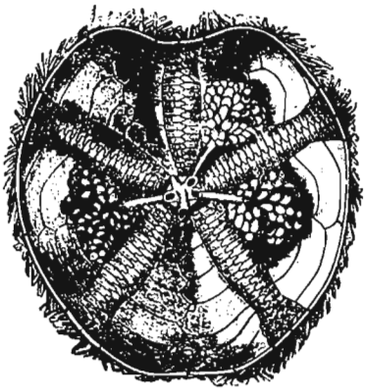


FIG. 145.—*Hemiaster cavernosus* (Phil.). The apical portion of the test of the male seen from within. Slightly enlarged.

radial areas; but the spines are so arranged that a kind of covered passage leads from the opening into the marsupium; and along this passage the eggs, which are remarkably large, upwards of a millimetre in diameter when they leave the ovary, are passed, and are arranged very regularly in rows on the floor of the pouch, each egg being kept in its place by two or three short spines which bend over it (fig. 146).

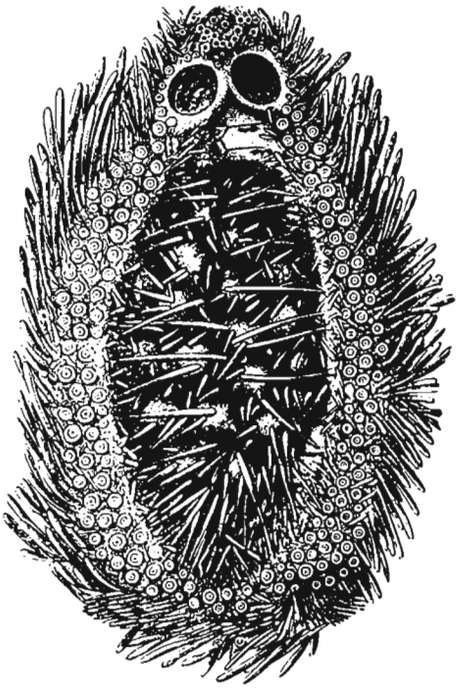


FIG. 146.—*Hemiaster cavernosus* (Phil.). The arrangement of the eggs in one of the marsupial recesses. Five times the natural size.

"Among the very many examples of this *Hemiaster* which we dredged in Accessible Bay, and afterwards in Cascade Harbour, Kerguelen, there were young in all stages in the breeding pouches; and although from the large size and the opacity of the egg and embryo it is not a very favourable species for observation, had other conditions been favourable, we had all the material for working out the earlier stages in the development of the young very fully. The eggs, on being first placed in the pouches, are spherical granular masses of a deep orange colour, enclosed within a pliable vitelline membrane, which they entirely fill. They become rapidly paler in colour by the development of the blastoderm; they then increase in size probably by the imbibition of water into the gastrula-cavity; and a whitish spot with a slightly raised border indicates an opening which, I have no reason to doubt, is the permanent

mouth; but of this I cannot be absolutely certain. The surface now assumes a translucent appearance, and becomes deeply tinged with dark purple and greenish pigment; and almost immediately, without any definite intermediate steps, the outer wall is filled with calcified tissue, it becomes covered with fine spines and pedicellariæ, a row of tentacular feet come into action round the mouth, the vent appears at the posterior extremity of the body and the young assumes nearly the form of the adult. These later changes take place very quickly; but they are accompanied by the production of so much heavy purple and dark green pigment that it is difficult to follow them. The viscera are produced at the expense of the abundant yelk; and the animals at once take a great start in size by the imbibition of water into the previsceral cavity. The young urchins jostle one another on the floor of the breeding pouch, those below pushing the others up until the upper set are forced out between the rows of fringing spines of the pouch; but even before leaving the marsupium, on carefully opening the shell of the young, the intestine may be seen already full of dark sand, following much the same course which it follows in the adult. The size of the test of the young on leaving the marsupium is about 2·5 mm. in length by 2 mm. in width.

"We took along with the last species in Stanley Harbour several specimens of a large species of *Asteracanthion* which formed a marsupium after the manner so well described by Sars in *Echinaster sarsii*, Müller, by drawing its arms inwards and forwards, and forming a brood-chamber over the mouth. In some samples of this species the young were so far advanced that when the mother was placed in a jar they crept out of the nursery and wandered over the glass wall of their prison; this brood had entirely lost the 'pseud-embryonic appendages,' but in their younger condition these are very apparent, though scarcely so well developed as in the young of *Asteracanthion violaceus* on our own coast.

"On the 27th of January 1874, at Station 149, off Cape Maclear on the southeast coast of Kerguelen Island, we dredged a handsome starfish allied to *Luidia* or *Archaster*, which has since been described by Mr. Edgar Smith, from specimens brought home by the Rev. Mr. Eaton, under the name of *Leptychaster kerguelensis* (fig. 147).

"A well-grown example is from 100 to 120 mm. in diameter from tip to tip of the arms; the length of the arm is about three times its width near the base, and three times the diameter of the disk. The marginal plates are long and narrow, running up with a slight curve outwards from the edge of the ambulacral groove until they meet the border of the dorsal perisome above; they are closely set with short blunt spines, which become gradually a little longer towards the radial groove; and at the edge of the groove each plate bears a tuft of about six rather long spines: these tufts in combination form a scalloped fringe spreading inwards on each side over the groove. The dorsal surface of the body is covered with a tessellated pavement composed of capitate paxilli. The heads of the paxilli in close apposition combine to form a mosaic with rudely hexagonal facets; and as they are raised upon somewhat slender shafts, whose bases, like the plinths of

columns, rest upon the soft perisome, arcade-like spaces are left between the skin and the upper calcareous pavement. The eggs pass into these spaces from the ovarial openings: on bending the perisome and separating the facets, they may be seen in numbers among the shafts of the paxilli. There is a continual discharge of ova into the passages, so that eggs and young in different stages of development occupy the spaces at one time. The young do not escape until at least six ambulacral suckers are formed on each arm; they

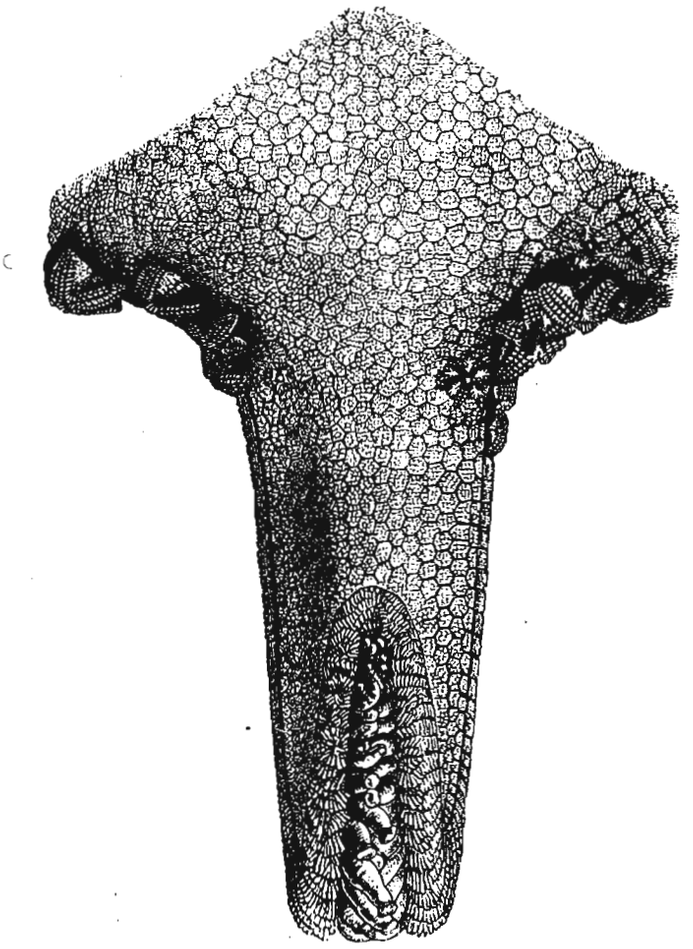


FIG. 147.—*Leptychaster kerguelensis*, E. A. Smith. Off Cape Maclear, Kerguelen Island. Twice the natural size.

may then be seen pushing their way out by forcing the paxilli to the side, and squeezing through the chink between them. While it is extricating itself the oral surface of the young is always above: and the centre of the star with the mouth is usually the part which first protrudes; then the arms disengage themselves one after another, many of the brood remaining for a time with one or two arms free and the others still under the paxilli. When the young have become disengaged, they remain for a considerable time attached to the parent by the centre of the dorsal surface. I could never satisfy myself

by what means this is effected; the attachment is very slight, and they are removed by the least touch. In this attached stage until they entirely free themselves, which they do when the number of tentacular feet on each arm has reached about twenty, they cluster in the re-entering angles between the arms of the mother, spreading a little way along the arms and on the dorsal surface of the disk; the young escape from the marsupium chiefly in the neighbourhood of the angles between the rays. The madreporiform tubercle is visible in the young near the margin of the disk between two of the arms; but in the mature starfish it is completely hidden by the paxilli, and no doubt it opens into the space beneath them.

"We took *Leptychaster* in the act of bringing forth young on that one occasion only; and the weather was so boisterous at the time that it was impossible to trace the early stages in the development of the embryo. It is evident that the process generally resembles that described by Professor Sars in *Pteraster militaris*, O. F. Müll.; and it is quite possible that, while there is certainly not the least approach to the formation of a locomotive bipinnaria, as in that species, some provisional organs may exist at an early period.

"In The Depths of the Sea (p. 120) I noticed and figured a singular little starfish from a depth of 500 fathoms off the north of Scotland under the name of *Hymenaster pellucidus*. This form was at that time the type of a new genus; but the researches of the last three years have shown that, with the exception perhaps of *Archaster*, *Hymenaster* is the most widely distributed genus of Asterids in deep water. It is met with (sparingly, it is true, only one or two specimens being usually taken at once in the trawl) in all parts of the great oceans; and it ranges in depth from 400 to about 2500 fathoms.

"On the 7th of March 1874 we dredged an extremely handsome new form, to which I shall give provisionally the name of *Hymenaster nobilis*, in lat. 50° 1′ S., long. 123° 4′ E., 1099 miles southwest of Cape Otway, Australia, at a depth of 1800 fathoms, with a bottom of Globigerina ooze, and a bottom temperature of 0°·3 C.

"*Hymenaster nobilis* (fig. 148) is 300 mm. in diameter from tip to tip of the rays; the arms are 55 mm. wide; and, as in *Hymenaster pellucidus*, a row of spines fringing the ambulacral grooves are greatly lengthened and webbed, and the web running along the side of one arm meets and unites with the web of the adjacent arm, so that the angles between the arms are entirely filled up by a fleshy lamina stretched over and supported by spines, the body thus becoming a regular pentagon. The upper surface of the body, the disk, and the arms,—all the surface except the smooth membrane between the arms,—are covered with fascicles of four to six diverging spines. These spines are about 3 mm. in height; and they support and stretch out a tolerably strong membrane clear above the surface of the perisome, like the canvas of a marquee, leaving an open space beneath it. A close approach to this arrangement occurs also in *Pteraster*.

"At the apical pole the upper free membrane runs up to and ends at a large aperture, 15 mm. in diameter, surrounded by a ring of five very beautifully formed valves. These

valves do not essentially differ from the ordinary radiating supports of the marsupial tent; a stout calcareous rod arises from the end of the double chain of ossicles which form the floor of the ambulacral groove. From the outer aspect of this support three or four spines diverge in the ordinary way under the tent-cover; but from its inner aspect six or eight slender spines rise in one plane with a special membrane stretched between them. When the valves are raised and the pentagonal chamber beneath them open, these spines separate from one another, and, like the ribs of a fan, spread out the membrane in a crescentic form (fig. 148); and when the valves close, the spines approximate and are

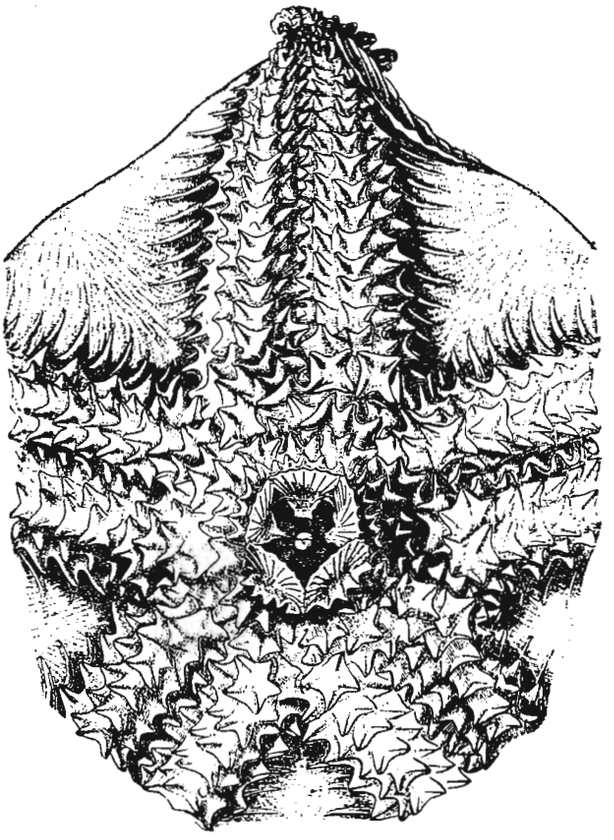


FIG. 148.—*Hymenaster nobilis*, Wyv. Thoms. Southern Ocean. Half the natural size.

drawn downwards, the five valves forming together a very regular, low, five-sided pyramid (fig. 149). Looking down into the chamber when the valves are raised, the vent is seen on a small projecting papilla in the centre of the floor; and between the supporting ossicles of the valves, five dark open arches lead into the spaces opposite the re-entering angles of the arms, which receive the ducts of the ovaries. In the particular specimen to which I have referred, which is considerably the largest of the genus which we have yet met with, there were one or two eggs in the pouch, but they were apparently abortive. It seemed that the brood had been lately discharged; for some oval depressions still

remained on the floor of the central chamber, in which the eggs or the young had evidently been lodged. I have on three occasions in species of the genus *Hymenaster* found the eggs beneath the membrane in the angles of the arms, and, in a more advanced stage, congregated in the central tent, but never under circumstances such that I could keep and examine them; exposed or loosely covered eggs or embryos, or any soft and pulpy organs or appendages, are always in a half disintegrated state when they are brought up from such great depths, if they have not been entirely washed away.

"As I have already said, *Hymenaster* is closely allied to *Pteraster:* the arrangements of the marsupium are nearly the same in both; and it is highly probable that, in *Hymenaster*, as in *Pteraster militaris*, a provisional alimentary tract may be developed in the early stages of the embryo.

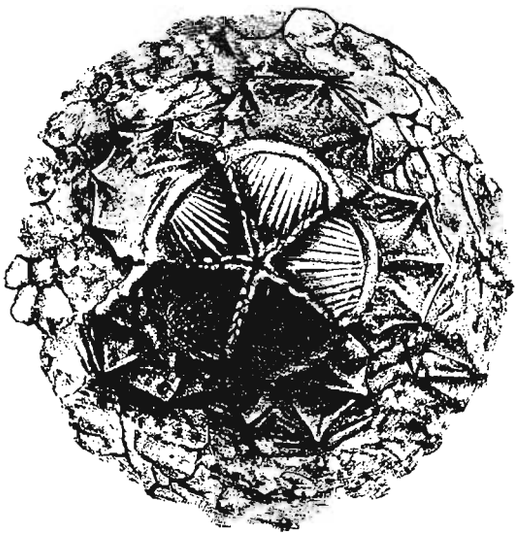


FIG. 149.—*Hymenaster nobilis*, Wyv. Thoms. The marsupial tent with the valves closed. Twice the natural size.

"There are several fine species of *Hymenaster* within reach of British naturalists in the deep water at the entrance of the Channel and off Cape Clear; but I fear there will be great difficulty in determining this point unless the genus turn up somewhere in shallower soundings where specimens can be taken alive.

"In Stanley Harbour, on the roots of *Macrocystis*, and also brought up free by the dredge, there were numerous examples of an Ophiurid which appears to correspond with *Ophiacantha vivipara*, Ljungman; we had previously got either the same or a very closely allied form in great abundance in the fjords of Kerguelen. The Kerguelen variety has been noticed by Mr. Edgar A. Smith,[1] under the name of *Ophioglypha hexactis*, and I have called it, provisionally, in a paper in the Proceedings of the Linnæan Society, *Ophiocoma didelphis*, from its opossum-like habit of carrying its young upon its back.

[1] *Ann. and Mag. Nat. Hist.*, ser. 4, vol. xvii. p. 3, 1876.

I do not think that it can properly be relegated to any genus at present defined, but it will doubtless fall into its place when the Ophiurids shall have been revised.

"The disk is about 20 mm. in diameter; and the arms are four times the diameter of the disk in length. The disk is uniformly coarsely granulated; the arm-shields, which are well defined through the membrane, are rounded in form and roughly granulated like the remainder of the disk. The character which at once distinguishes this species from all the others of the genus is, that the normal number of the arms is six or seven instead of five, which is almost universal in the class. The number of arms is subject

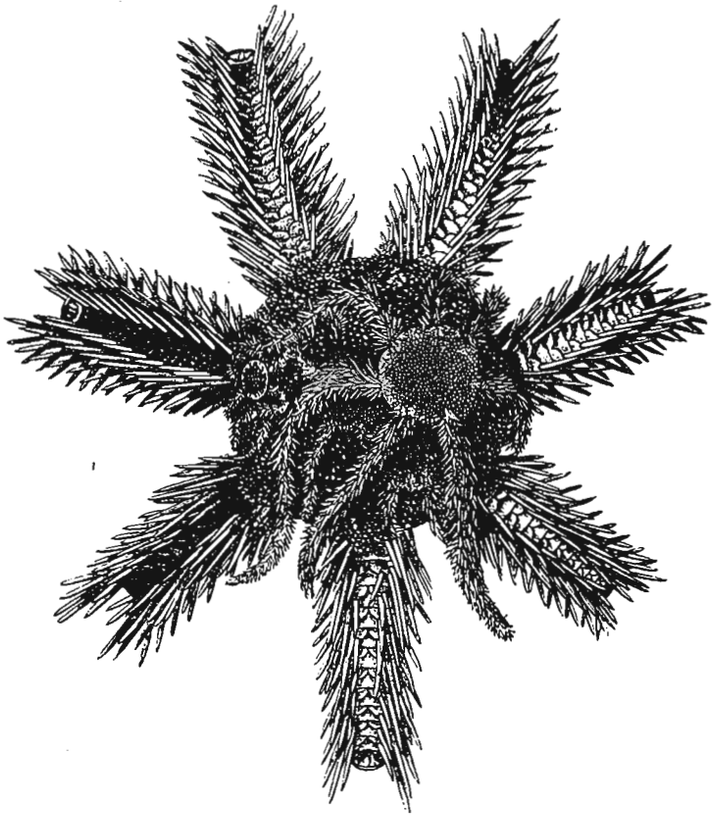


FIG. 150.—*Ophiacantha vivipara*, Ljungman. Falkland Islands. Twice the natural size.

to certain variation. I have seen from six to nine, but never fewer than six. The arm-spines are numerous and long. The general colour of the disk and arms is a dull greenish brown.

"A large proportion of the mature females, if not all of them, had a group of from three to ten or twelve young ones clinging to the upper surface of the disk by their arms: the largest of these were about a quarter the size of their mother; and they graduated down in size until the smallest had a diameter of less than 1·5 mm. across the disk. The largest and oldest of the progeny were always uppermost, farthest from the disk, the

series decreasing in size downwards, and the supply evidently coming from the genital clefts beneath. In several specimens which I examined, although by no means in all, there were groups of eggs and of young in still earlier stages, free in the body-cavity in the interbrachial spaces.

"It thus seems that in this case the true 'marsupium' is a portion of the body-cavity, and that the protection afforded by it is supplemented by the attachment of the young to the surface of the disk, maintained for some time after their extrusion or escape.

"The process of propagation in *Ophiacantha vivipara* differs from most of the other cases described, in the eggs being successively hatched, and the young being found consequently in a regularly graduated series of stages of growth. Although I had not an opportunity of working the matter out with the care and completeness I could have wished, I feel satisfied, from the examination of several of the young at a very early period, that in this case no provisional mouth and no pseudembryonic appendages whatever are formed, and that the primary aperture of the gastrula remains as the common mouth and excretory opening of the mature form. From the appearance of the ovaries and of the broods of young, I should think it probable that this species gives off young in a continuous series for a considerable length of time, probably for some months.

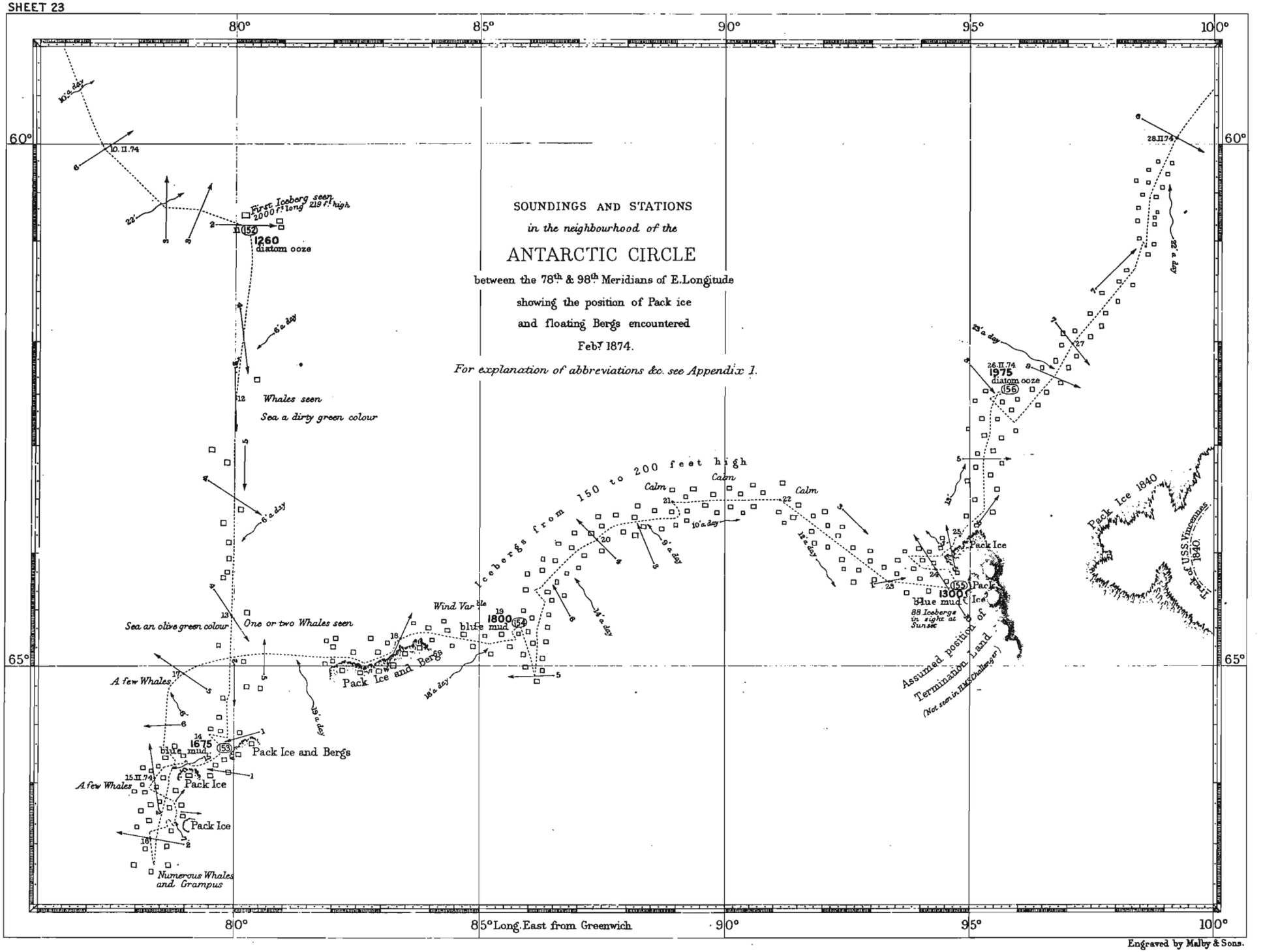
"I have selected these illustrations of the development of the young of Echinoderms from the egg without the intervention of a locomotive 'pseudembryo' from a much larger number. As I have already said, I cannot, on account of the unfavourable conditions for carrying on such investigations under which the majority of the species were procured, say with certainty that no trace of pseudembryonic appendages or provisional organs exist in any of these instances, but I feel satisfied that none such occurs in *Psolus ephippifer*, in *Hemiaster cavernosus*, or in *Ophiacantha vivipara*. Neither am I in a position to state that in these southern latitudes direct development is universal in the sub-kingdom. I believe indeed that it is not so; for species of the genera *Echinus*, *Strongylocentrotus*, and *Amblypneustes* run far south, and a marsupial arrangement seems improbable in any of these. It is, however, a significant fact that, while in warm and temperate seas 'plutei' and 'bipinnariæ' are constantly taken in the surface-net, in the Southern Ocean they are almost entirely absent."

From Heard Island to the Antarctic Circle and Australia.

It will doubtless be interesting to navigators to know how the Challenger fared when cruising in the little-known region of the Antarctic and among the ice, therefore the various movements of the ship are here given in detail.

On the 8th February, at 1 A.M., a heavy sea struck the ship and stove in the two

SHEET 23



Engraved by Malby & Sons.

foremost ports on the starboard side of the main deck, floating everything out of the sick-bay, but fortunately there was no one ill enough to be occupying the swinging cots. The gale broke shortly after this accident, and the barometer beginning to rise, at 4 A.M. courses were set and the vessel bore up to the southward. At 8 A.M. the wind had moderated sufficiently to allow of all plain sail being made, and the day was beautifully clear, with a fairly dry atmosphere, which was appreciated after the five days' mist in the vicinity of Heard Island. This fine weather enabled the ship to keep running south all night, a sharp look-out being kept for icebergs, but none were seen although the vessel was in lat. 56° S.

On the 9th the weather still continued fine and clear, and the breeze moderate. A few light squalls accompanied with snow were experienced, during which the minimum thermometer fell to freezing point. No icebergs were sighted. In the afternoon the weather appeared very settled, with high clouds and a steady barometer (29·017 inches), and a view of from 15 to 20 miles was commanded from aloft.

On the 10th a fresh breeze was experienced all day till 6 P.M., the anemometer giving a velocity of 19 miles per hour, the barometer standing at 29·050 inches, but seeming towards evening inclined to rise. Mean temperature in shade 33°·8; position at noon, lat. 60° 2′ S., long. 77° 20′ E. No ice seen. The direction of the wind (S.W. by W.) prevented the ship being steered towards the spot in lat. 60° S., long. 72° E., where Biscoe and Kemp reported the appearance of land in 1833–34, and the absence of icebergs appeared to indicate that they were deceived. Occasional snow squalls were experienced, which limited the range of vision to from two to four miles.

On the 11th, at 2.50 A.M., the first iceberg was sighted. At 5 A.M. sails were furled,

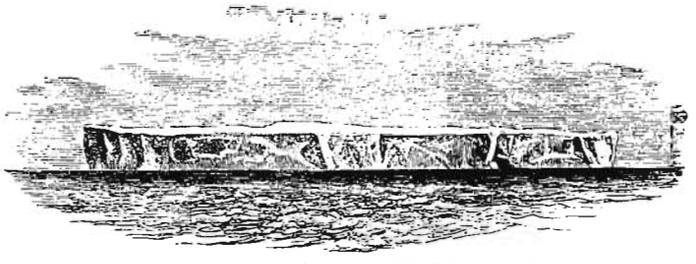


FIG. 151.—Iceberg first seen, 11th February 1874.

and a sounding, trawling, and serial temperatures were taken in 1260 fathoms, Diatom ooze, Station 152 (see Sheet 23). The cutter moored to the trawl line showed the surface current to be setting N.E. true, one-third of a mile per hour, agreeing in direction, though not in velocity, with the result obtained by astronomical observation. The position of the ship was lat. 60° 52′ S., long. 80° 20′ E. The iceberg originally seen was in sight during the trawling operations, and was found to be, by angular measurement, 219 feet high and 2100 feet in length; if a cube, its depth under water would be about 1800

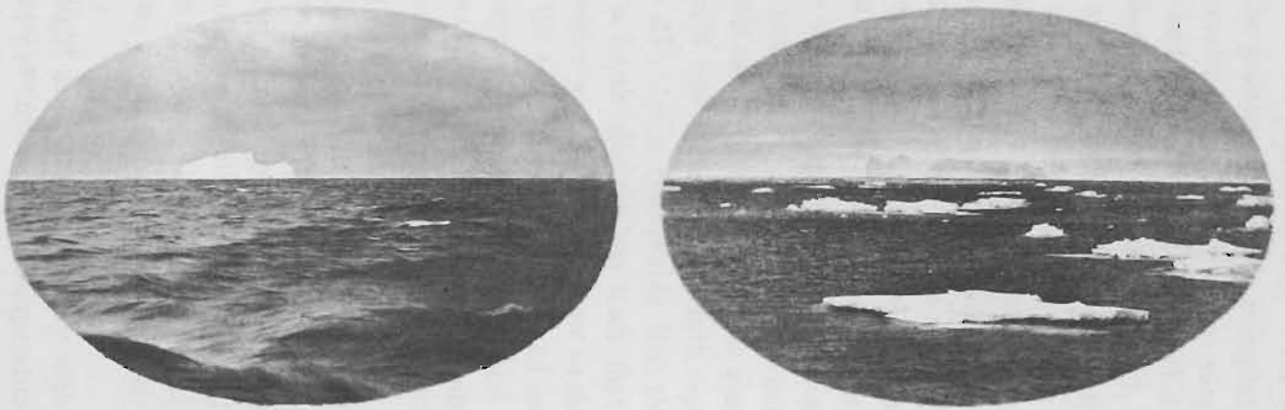
feet. It was one of the table-topped bergs, and appeared to be quickly disappearing, for it calved in the forenoon, making a considerable commotion in the water near it.

Considerable difficulty was experienced in obtaining any satisfactory temperature observations, as the thermometers, when lowered to greater depths, came up showing the same result as at 50 fathoms.

At 2.30 P.M. the trawl came up fouled, although with a few specimens. Whilst trawling two pieces of drift ice were seen to the eastward; as these were not visible when sounding operations were commenced, and the ship remained stationary whilst trawling, they must have drifted into view. At 3.30 P.M. sail was again made to the southward. At 9 P.M. a piece of drift ice was passed about 100 feet long and 6 feet high, probably the remains of an old berg. The weather during the day was cloudy, but the sun was visible occasionally for a few minutes, so that the position could be ascertained; the horizon was clear and the sea moderate, and a view of 15 or 20 miles commanded from the masthead. A White Petrel was seen during the first watch. The barometer rising; temperature of air, 34°·7.

On the 12th, at 9.50 A.M., a peaked berg about 100 feet high was seen to the E.S.E., and at 5.40 P.M. two others, one to the southward, and the other to the westward; at 6 P.M. the ship passed close by the southward berg, which was about 60 feet high, with a little drift ice in its vicinity, and of a beautiful cobalt blue colour near its base. At 8 P.M. no ice was in sight. A little before midnight another berg was seen to the southward. The weather during the day was overcast, with a drizzling rain, which on one occasion was so thick as to necessitate laying to, for vision was limited to from a quarter of a mile to 4 miles, the wind being northerly in direction and variable in strength. The barometer stood at 29·500, but fell to 28·862 inches at midnight. No Penguins had been seen since leaving Heard Island. At 11 P.M. the vessel "hove to" until daylight, just in time to avoid collision with an iceberg.

On the 13th, at 2.45 A.M. (daylight), sail was again made to the southward; two icebergs in sight. In the morning watch three others were passed, in addition to several pieces of wash ice. At noon, in lat. 64° 38′ S., long. 80° 0′ E., one berg only was in sight. In the afternoon two additional bergs were sighted and passed, and at 7.40 P.M. the ship passed within a cable's length of the seventeenth berg, which was a peaked one about 100 feet high. Between 8.30 P.M. and 10 P.M. two more bergs were passed, and at 11 P.M. the vessel ran into a quantity of brash ice, with numerous bergs to the southward, and so hauled to the wind on the starboard tack for the night. The weather on this day was fairly fine, the sun visible from noon until 3 P.M., and the horizon clear. The wind moderate; the barometer steady at 28·781 inches. Temperature of the air 34°, of the sea surface 33°, but this fell to 29°·5 when the brash ice was entered. No Albatrosses seen, but numerous Cape Pigeons and Prions, and a few Whales.



HORSBURGH, EDINBURGH.

PERMANENT PHOTOTYPE.

ANTARCTIC ICE.

On the 14th, at 3 A.M., the ship wore and stood in towards the brash ice, and at 6 A.M. sails were furled, steam got up, and a sounding, dredging, and serial temperatures were taken in 1675 fathoms, blue mud, Station 153 (see Sheet 23). Pack ice and numerous bergs were in sight to the southeastward, the position of the ship being lat. 65° 42′ S., long. 79° 49′ E.

The serial temperature observations on this date were very successful, as some of the brash ice could be collected, and the thermometers cooled before immersion. Each thermometer when immersed showed a temperature of 30°·2, both on the maximum and minimum sides. At 50, 100, and 200 fathoms they came up registering 30°·2 on the maximum side, and 29° on the minimum side, showing that to the depth of 1200 feet the water was at a uniform temperature of 29°. The thermometers sent down to the depth of 300 and 500 fathoms, and to the bottom, gave different results, for at 300 fathoms the maximum index registered a temperature of 32° and the minimum 29°; at 500 fathoms the maximum index registered 32°·8 and the minimum 29°, and at the bottom the maximum was 33° and the minimum 28°·8. These results show that below the depth of 200 fathoms the temperature of the water rose gradually to 32°·8 at about 500 fathoms, but, unfortunately, it was impossible to tell what happened below that depth, as the thermometer came up showing the same result as at 500 fathoms. It was a matter of much regret that the bottom temperature could not be ascertained with certainty, it cannot, however, be less than 28°·8 nor more than 33°. It is remarkable that the water retains a temperature of 29° to 200 fathoms, or a depth slightly less than that of the icebergs, and that the temperature of the surface water was 33°, or the same as that of the warm underlying strata a few miles northward of the edge of the brash ice and icebergs, which would point to the conclusion that the cold upper layer was only local, and that it did not sink to the bottom, the greater specific gravity, due to its lower temperature, being more than counterbalanced by the admixture of the snow water from the bergs.

At 3.30 P.M., after heaving in the dredge, sail was made, the ship standing to the westward along the edge of the pack ice. At 6 P.M. there were forty-seven bergs in sight, and the pack extended from south to east, with apparently open sea to the southwestward. At 8 P.M. more pack ice was seen extending from W.N.W. to S.E., so at 10.30 P.M. the ship hauled to the northward under easy sail. The weather during the day was cloudy (occasionally misty), with passing snow showers, the wind light and variable, the barometer steady at 28·765 inches, mean temperature of the air 32°·5, the range of vision limited to about four miles.

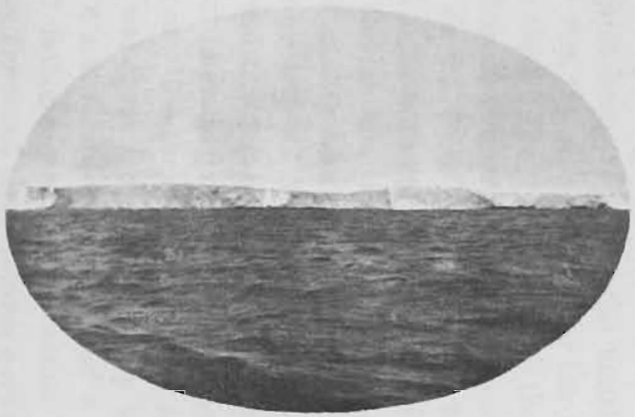
On the 15th the wind was light and variable all day with a smooth sea and a clear horizon. Barometer steady at 28·827 inches, mean temperature of air 29°, of sea surface 30°·7. Position at noon, lat. 65° 59′ S., long. 78° 24′ E. Pack ice and numerous icebergs seen throughout the day. The icebergs seen on this and the previous day were mostly tabular, from 100 to 200 feet in height.

During the calm weather numerous Cape Pigeons were observed on the tabular bergs,

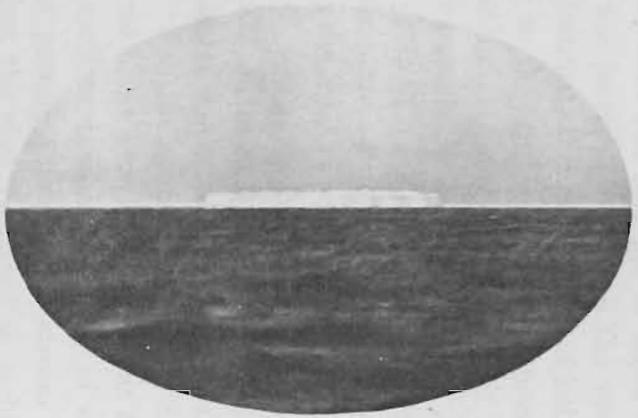
and had they not been seen breeding at Heard Island it might have been fancied that they used the ice for the purpose.

On the 16th, at 2 A.M., the ship again running into a quantity of brash ice, which was apparently thick from S.W. to W. by N. the vessel wore round to the northwards. At 4 A.M. a large number of icebergs were in sight; one being pyramidal in shape and of a peculiar blue colour like a turquoise; at 7 A.M. it fell calm, and the sea being smooth steam was got up in order, if possible, to effect a landing on the ice, and obtain a series of magnetic observations free from the local errors of the ship. Although the sky overhead was clouded the atmosphere was remarkably clear, so that objects 20 miles distant appeared only five or six miles off, so much so that icebergs at that distance seemed from the masthead to be a line of unbroken pack, or a large floe, but on steaming towards them always turned out to be the usual tabular bergs. Some of these were very large, at least four miles in length, but all about the height of 200 feet, and all with steep, inaccessible sides. At 10 A.M., seeing no chance of effecting a landing on the ice, the small pieces in the pack rising and falling with the swell, and the bergs being inaccessible, sail was made and the vessel stood to the southward. Although the sky overhead was covered with an impervious cloud all the forenoon, so that the position of the ship could not be ascertained by astronomical observation in the early part of the day, the sun was shining on all the distant bergs, and there were no clouds of any description near the horizon from S.W. to S.E. (true).

At 2.30 P.M., having stood 10 miles southward of the Antarctic Circle, the vessel tacked and stood to the northward. At this time there was no pack ice in sight but a large number of icebergs as far as the eye could reach, some of them certainly two or three miles in length. The clear sky to the southward was just what could have been wished had the object been to attain a very high latitude, for land of any elevation would certainly have been seen at a distance of 50 or 60 miles had it existed. The object, however, was not to attain a particularly high latitude, but merely to make observations on the temperature and depth of the sea in the vicinity of the ice, and it would have been foolish to go farther south in an unfortified ship with only six months' provisions on board. At 3.30 P.M. the sun shone out, and at 5 P.M. a double altitude was obtained which gave the position. At 2.30 P.M., when the ship tacked to the northward, the position was lat. 66° 40′ S., long. 78° 22′ E. The absence of pack ice at the turning point indicated that the pack seen on the two previous days was a detached floe. A number of Penguins on small detached pieces of ice were passed during the day, and several Whales were seen. The weather was fine all day, calm in the forenoon, an easterly breeze in the afternoon, which gradually freshened; the barometer steady at 28·800 inches till noon, after which it fell; the mean temperature of the air 29°, and of the surface water 30°·5. At 8 P.M. the topsails were double reefed, and at 11 P.M. the ship hove to, the weather having become misty and snow squalls passing over.



HORSBURGH, EDINBURGH.



PERMANENT PHOTOTYPE.

ANTARCTIC ICE.

On the 17th, at 3 A.M., the vessel stood to the eastward, close hauled on the starboard tack. At 4 A.M. there were two icebergs in sight, at 8 A.M. one, and at noon none. At 4 P.M. a small berg was passed, after which the vessel appeared to be to the northward of the chain. It is fortunate that the number of icebergs diminishes so rapidly from the pack ice; on running to the southward only seventeen icebergs were passed in 200 miles, and then the ship ran into a chain of them within 15 or 20 miles of the edge of the pack. Cook and Wilkes remark the same peculiarity. On the previous evening the vessel ran quite out of the chain of bergs, and during the night never more than two were in sight at one time. A fresh breeze was blowing with cloudy, gloomy weather and occasional snow squalls all day, the limit of vision being two to three miles, the wind shifting gradually to S.E. and S. (true), the barometer standing fairly steady at 28·639 inches, temperature of the air 29°·7, of the surface water 32°·5, the sea a dirty green colour; towards evening the weather cleared so that the ship was enabled to stand on all night, there being few bergs in sight. Position at noon, lat. 65° 5′ S., long. 78° 55′ E.

On the 18th at daylight three bergs were in sight, and at 4 A.M., five. At 6.40 A.M. the pack ice was seen to the southward, with a quantity of stream ice off it, and from 7 A.M. until noon the ship was passing through this stream ice. At noon the vessel passed out of the stream ice, but the pack remained in sight until nearly 4 P.M., and numerous bergs were visible, twenty being counted at 2 P.M. This pack ice was quite close, no lanes of water through it being seen from the masthead. At 4 P.M. the pack was lost sight of astern. At 8 P.M. the ship hove to for the night in consequence of a heavy snowstorm obscuring the view. The weather during the day was fine until 8 P.M. with a S.S.W. wind (true), the barometer rising slowly and steadily from 28·704 to 28·879 inches, mean temperature of air 25°·6, of surface water 30°·8. Position at noon, lat. 64° 44′ S., long. 83° 26′ E. The minimum thermometer fell to 22°. The atmosphere was rather misty round the horizon, the upper parts of some of the distant bergs being capped with mist, but the sun broke through the clouds occasionally. Close to the pack the surface temperature was 27° to 29°, at a little distance from it 32° to 33°. The stream ice, through which the ship passed in the forenoon, consisted of lumps of water ice some 20 to 30 feet in diameter with snow on their upper sides; the vessel came into collision with a piece now and then which gave her a good bump.

On the 19th, at 2 A.M., sail was again made and the ship stood to the eastward, but the wind having died away by 8 A.M. steam was got up and a sounding and serial temperatures were taken in 1800 fathoms, blue mud, Station 154, in lat. 64° 37′ S., long. 85° 49′ E. (see Sheet 23). The serial temperatures gave much the same result as on the 14th, the temperature falling to 29° at 50 fathoms, and remaining at that to 200 fathoms, afterwards rising to 33° at 300 fathoms. At noon sail was made on the port tack to a light easterly breeze, but at 4 P.M., there being many icebergs in sight, the ship tacked and stood to the northward to get into a clearer sea before dark, and at 10.30 P.M.

hove to until daylight. At 6 P.M. forty bergs were counted from the masthead. The weather continued fine during the day, with a smooth sea and a moderate east wind (true), the clouds were more detached than usual, the sun being visible at intervals during the whole day. The atmosphere rather misty, the barometer steadily falling from 28·880 to 28·515 inches, temperature of air 29°, of surface water 32°·4.

On the 20th, at 3 A.M., sail was made on the starboard tack, the easterly wind preventing the ship getting towards Wilkes' Termination Land as quickly as was desired. Numerous bergs were in sight all day, at one time sixty-nine were counted, but no pack ice was seen. At 10.30 P.M. the vessel was again obliged to heave to under topsails and jib for the night. A moderate breeze blew from the southeast all day, the sky being overcast, and the sea smooth, the barometer gradually rising from 28·533 to 28·828 inches. Temperature of the air 29°·5, and of the sea surface 32°·6. Some Penguins and Whales were seen in addition to the usual sea birds.

On the 21st the weather was calm all day, cloudy and misty in the forenoon, but

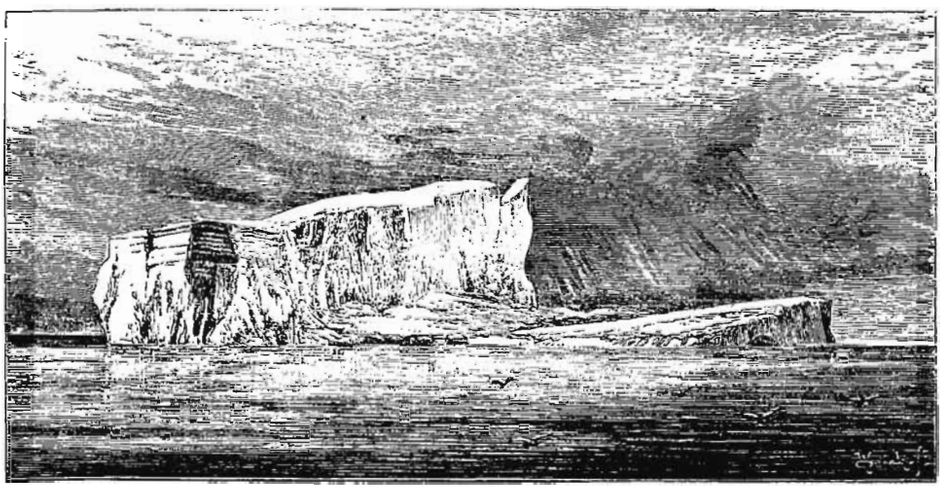
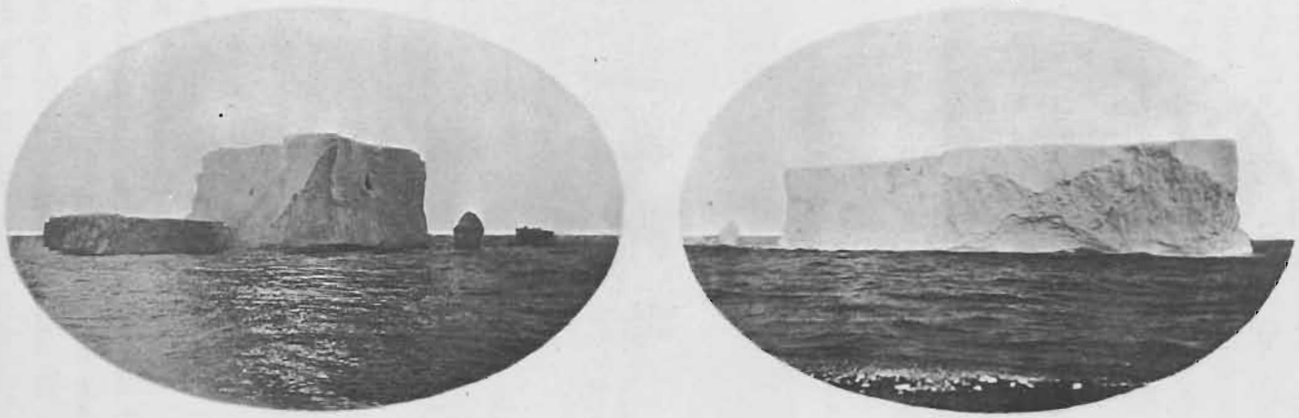


FIG. 152.—Iceberg seen 21st February 1874.

clear in the afternoon and evening. Numerous icebergs were in sight, seventy-eight being counted from the deck. At 4 P.M., the weather still remaining calm, steam was got up and the ship proceeded towards an iceberg about one mile distant; stopping close to the berg it was photographed, and afterwards the 12-pounder was fired at it. The first shot was directed at a low part of the berg about 100 feet from the ship, and striking against pure ice split off a great mass from the ice-cliff, which, tumbling into the water between the berg and the ship, created quite a commotion. The second shot was directed at the upper part of the berg about a third of the distance below the summit, which was 180 feet high, and striking against the softer part merely buried itself in the snow-cliff. The sun shining out at this time the opportunity was taken of swinging the ship to ascertain



HORSBURGH, EDINBURGH. PERMANENT PHOTOTYPE.

ANTARCTIC ICE.

the deviation and variation of the compass, this being the first opportunity experienced of doing so since leaving the Cape of Good Hope. Having completed swinging at 7 P.M. the vessel proceeded under easy steam to the eastward. At 10 P.M. a fine aurora lit up the surrounding icebergs. During the afternoon serial temperatures were obtained at every 10 fathoms to 50 fathoms, which showed a gradual decrease from 32° at the surface to 29°·3 at 40 fathoms. The barometer was steady at about 28·810 inches, temperature of the air 29°·8, temperature of sea surface 32°·4; position at noon, lat. 63° 30′ S., long. 88° 57′ E.

On the 22nd, the weather continuing calm all the forenoon, and steam being up, the ship was swung to ascertain the errors of the dipping needle, which took until 2 P.M., when a westerly breeze having sprung up all sail was made towards Termination Land. Numerous icebergs were in sight all day, thirty-two being counted at 4 P.M., but no pack ice was seen. Several of the bergs passed had perpendicular fractures extending

FIG. 153.—Iceberg seen 23rd February 1874.

from the summit some way down their sides. The weather during the day was fine with a light wind and smooth sea, cloudy in the forenoon, but bright and sunny in the afternoon, the barometer rising slowly and steadily from 28·796 to 29·096 inches. Mean temperature of air 31°·4, of sea surface 32°·8. On the 21st and 22nd there was a heavy bank of clouds to the northward; the view on the latter date was uninterrupted from east round south to west, but was limited to about 8 or 9 miles in the northern part of the horizon. The position at noon was lat. 63° 30′ S., long. 91° 11′ E.

On the 23rd the ship hove to just after midnight until 2 A.M., the horizon ahead being darkened by a heavy bank of clouds. At daylight the weather cleared, and the day was remarkably fine with smooth water and a clear atmosphere. The wind falling light at noon steam was got up and the vessel proceeded towards Termination Land,

then distant about 45 miles. Numerous icebergs were in sight. During the afternoon the ice blink was seen ahead, and at 6 P.M. the pack was plainly in sight from E. by S. to S. by W. (true). At 7.30 P.M. the ship stopped off the edge of the pack in lat. 64° 18′ S., long. 94° 47′ E., but although the horizon was clear to the eastward nothing was seen of Wilkes' Termination Land, the supposed position of which was then 20 miles east. The pack preventing the vessel steaming farther east, a sounding was obtained in 1300 fathoms, blue mud, Station 155 (see Sheet 23), and then the ship laid to for the night under gaff mainsail and jib. At 5 P.M. eighty-eight icebergs were counted from the deck. At sunset the horizon was remarkably clear to the southward and eastward, but to the northward there were dense masses of cumulus cloud, and the sky had a hard appearance. The barometer rose from 29·103 to 29·163 at 2 P.M., and then fell to 29·039 inches at midnight. Mean temperature of the air 31°·3, of the sea surface 32°·1. During the day an iceberg was passed with a large rock on it, the first hitherto seen, the berg was too far off to distinguish the nature of the rock, or whether it had on it more than one. The bergs passed were nearly all tabular.

On the 24th, at 4 A.M., the dredge was put over, but the barometer falling quickly

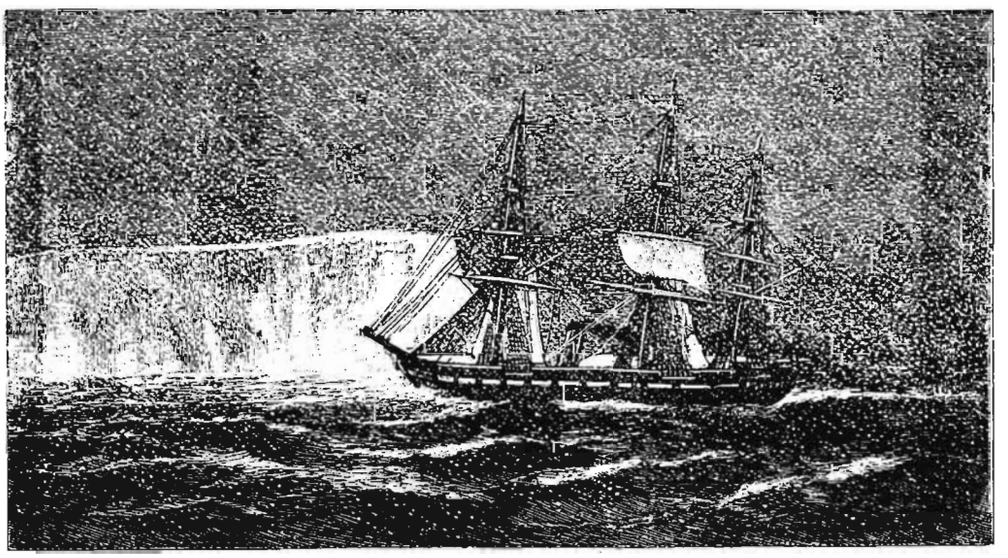
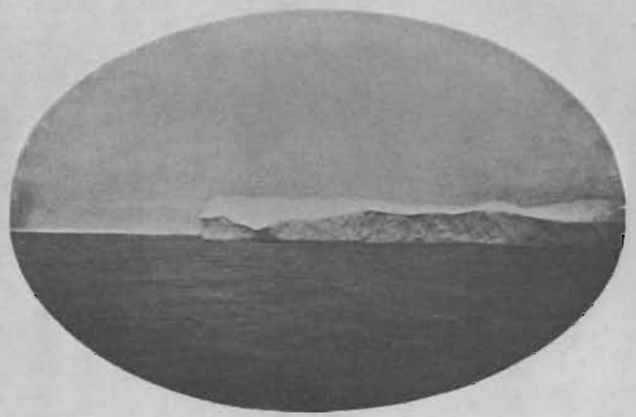
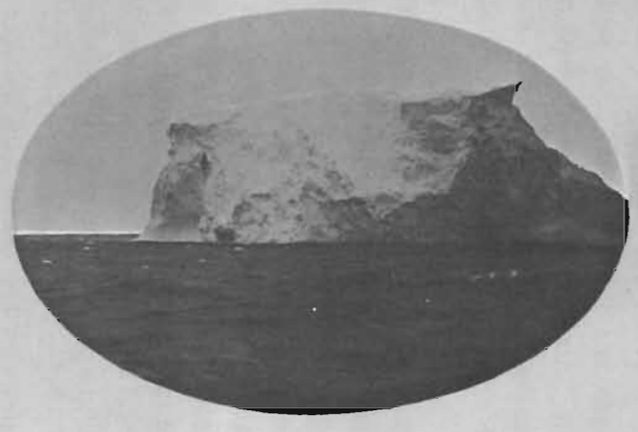


FIG. 154.—H.M.S. Challenger after collision with an iceberg, 24th February 1874. From a sketch by Lieut. Aldrich, R.N.

and a southeasterly wind springing up and rapidly increasing to a gale, it was hove up at 9 A.M. empty. At this time the weather looked very threatening, and snow began to fall, so the ship steamed under the lee of a berg and the topsails were close-reefed. Whilst keeping head to wind under the berg, steaming slowly, a sudden lull for a minute, by removing the force against which the screw was acting, caused the ship to gather headway, and before the engines could be stopped the vessel ran into the berg and carried away the jib-boom, martingale, and one of the whiskers. The ship was

Plate XIII.





HORSBURGH, EDINBURGH.

PERMANENT PHOTOTYPE.

ANTARCTIC ICE.

backed astern clear of the berg, and having finished reefing and furled the topsails, laid to under fore and aft sails on the port tack to get in the wreck of the jib-boom. The weather continued to get gradually worse, and the heavy snowfall obscuring the view, rendered the position an anxious one. From 8 to 9 A.M. the velocity of the wind was 24 miles per hour, from 9 A.M. to noon 37 miles per hour. At noon steam was got up in all four boilers, and the main deck ports barred in to prepare for all emergencies, the velocity of the wind was 42 miles per hour, and the vision limited to a distance of a quarter of a mile by the heavy snowfall.

At 2.45 P.M., in the thickest part of a squall, the loom of a large iceberg was seen at the lee bow. As the ship was drifting down on it, and there was no room to steam ahead, the vessel went full speed astern, took in the fore trysail and staysail, and set the weather clue of the main topsail aback, the yards having been previously laid. Fortunately, the ship gathered stern-way, and kept fairly broadside to the wind until the berg was cleared. An attempt was then made to steam up under the lee of this iceberg and use it as a breakwater, but with full power steam and close-reefed after sails the ship refused to face the wind, so it was again necessary to lay to and drift. After doing so for about half a mile another large berg was seen during a lull in the snowfall half a mile ahead. The ship was accordingly allowed to drift towards it, and the wind moderating slightly, was able to tack under its lee with steam and fore and aft sails, and then return towards the berg which had been nearly fouled. Having proved the space between the two bergs to be free from danger, the anxious night was spent going from one to the other. At 4 P.M. the velocity of the wind decreased from 42 to 37 miles per hour. At 7 P.M. the snow squalls ceased, and the limit of vision was increased to three or four miles; there were then thirteen bergs in sight. After 8 P.M. the wind began to moderate.

The barometer fell rapidly as the wind freshened, reaching its lowest point (28·508 inches) at 10 P.M.; the mean temperature of the day was 25°·8, falling to 22°·8 at 6 P.M.; the sea surface temperature was 31°·6. It was extremely fortunate that the gale broke and the snow ceased before night; had it continued with sufficient force to prevent the ship maintaining a position between two known bergs during the darkness, it would have been very difficult to avoid a collision with the ice.

On the 25th, at 3 A.M., the wind having moderated to force 5, and the weather being fairly clear, sail was again made towards Termination Land; as the vessel proceeded towards the pack the berg was passed which had been fouled early on the previous day, the score on its surface made by the jib-boom remaining well-defined notwithstanding the heavy fall of snow. At 9 A.M., being close to the edge of the pack, which was here very loose, the ship ran into it for a distance of a mile, to get as near Termination Land as practicable, and to examine the nature of the ice composing the pack. A boat was lowered and some pieces of the ice collected, some of which was of a dirty yellow colour,

caused, as was afterwards found, by the number of Diatoms, Foraminifera, and other surface animals in it.

The pack was precisely similar to that described by Ross when he entered it on 5th January 1841. It consisted chiefly of small floes of last winter's formation, with a quantity of hummocky ice of much older date, forced by great pressure into heavy masses. The floe pieces were usually some 30 to 50 feet in diameter, and from 3 to 7 or 8 feet in thickness, much honeycombed, and with their surfaces covered by a thin layer of snow about a foot in thickness. It appeared to be decaying rapidly, but would still evidently give a ship a dangerous squeeze if massed against a berg by a strong wind, and a ship sailing through it should be prepared for an occasional hard knock. To avoid collision with these lumps the ship entered and left the pack under very easy sail. It was hoped that a suitable piece of ice would be found on which to

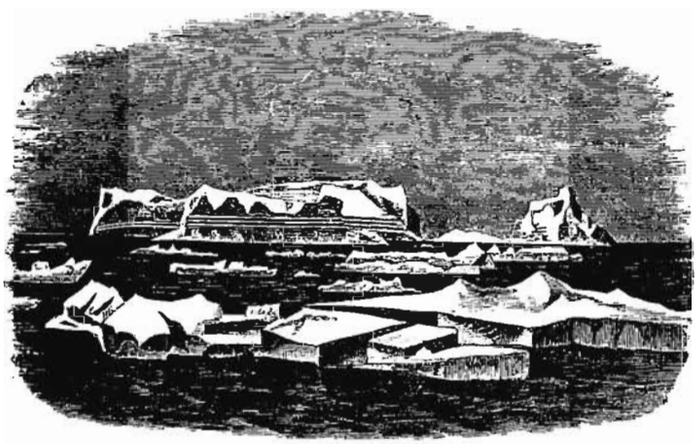


FIG. 155.—Iceberg and Pack Ice, seen 25th February 1874.

obtain magnetic observations, free from the influence of the ship's iron, but no opportunity of doing this presented itself. The westerly swell caused too much motion amongst the floe pieces, even had they been large enough to bear the weight of the instruments and observers, and the swell broke too heavily against the sides of the bergs; besides which a fit place for landing was never found, even on their leeward sides. In the middle of a pack Ross found the floes he landed on had motion, although not sufficient to prevent his observing, and Moore, like the Officers of the Challenger, did not succeed in meeting a suitable platform amongst the ice for taking observations. The southern pack is certainly much more dangerous to a ship during bad weather than the northern, as there the floes are usually sufficiently large to permit a dock to be cut. In the Antarctic no shelter can be obtained. Again, the northern ice is easier of navigation, for a breeze off the land will often open a

channel for 20 or 30 miles, whereas in the Antarctic as soon as one piece is blown to leeward its place is occupied by another; however, except in a very heavy pack, there is more chance of escaping collision with a berg in the Antarctic than in the Arctic. The temperature of the water in the pack was 29°. Ross generally registered 28°. After getting clear of the pack at 11 A.M. the ship sailed along its edge until noon, being from 10 A.M. until that time within about 15 miles of the supposed position of Wilkes' Termination Land, but neither from the deck nor masthead could any indication of it be seen. The limit of vision as logged was 12 miles, and had there been land sufficiently lofty for Wilkes to have seen it at a distance of 60 miles (which was the distance he supposed himself off it), either the clouds capping it or the land itself must have been seen. If Wilkes' distance was overestimated, that of the Challenger would be increased, and it may still be found, but as the expression in Wilkes' journal is "appearance of land was seen to the southwest, and its

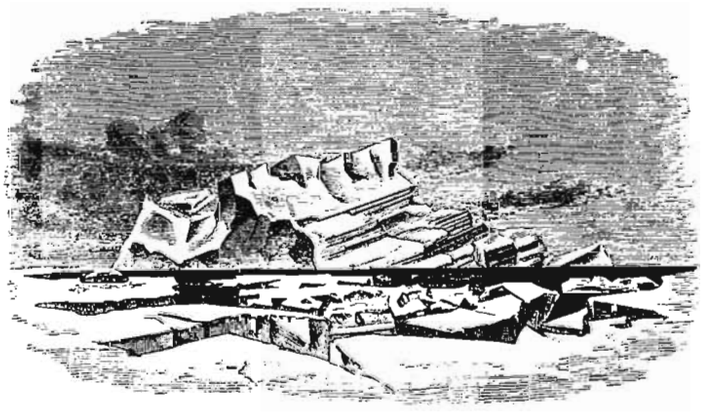


FIG. 156.—Iceberg and Pack Ice, seen 25th February 1874.

trending seemed to be to the northward," and not that land was actually sighted, and a bearing obtained, it is probable that Termination Land does not exist; still it is curious that pack ice and a large number of bergs should have been found in nearly the same position as by Wilkes in 1840, and this would seem to indicate that land cannot be very distant. At noon the northern part of the pack was reached, and it was found to trend to the southeast (true), the position being lat. 63° 49′ S., long. 94° 51′ E. As no advantage was to be gained by following the pack 80 miles to the eastward, until it joined Wilkes' main pack, and as Moore, Cook, and Wilkes had seen much ice north of this position, the vessel stood to the northward with a fine southwesterly breeze.

It is a fair indication of the limit to the navigable season in the Antarctic if the dates each explorer has turned his ship's head to the northward and left the edge of the pack be compared, as in the following table :—

Explorer.	Year.	Date of turning North.	In Lat.
Cook, ...	1773	January 17th	67°
Wilkes, ...	1840	,, 26th	65°
Cook, ...	1774	,, 30th	71°
Weddel, ...	1823	February	74½°
Wilkes, ...	1840	,, 24th	64°
Nares, ...	1874	,, 25th	63½°
Moore, ...	...	March 3rd	64½°
Ross, ...	1843	,, 5th	71½°
Ross, ...	1842	,, 7th	64°
Ross, ...	1841	,, 20th	65°

Both Ross and Cook were running along the 60th parallel considerably after the date mentioned, but they both speak of the danger of doing so during the dark nights. Unless favoured by the moon or clear weather, no vessel should attempt to proceed on her voyage between 8 P.M. and 4 A.M. whilst among icebergs; that is, south of about lat. 58° S.

At 8 P.M. sail was shortened and the ship hove to for the night. The weather during the day was cloudy and gloomy, but the sun shone out for a few minutes now and then, so that the position could be ascertained by astronomical observation. The wind was moderate and the sea smooth, the barometer rising steadily from 28·537 to 29·023 inches; the mean temperature of the air 28°·6, of the surface water 31°·9. Numerous icebergs were in sight all day.

On the 26th, at 3 A.M. (daylight), sail was made, and the vessel stood to the northward. At 9 A.M., the weather being fine with a high barometer for these regions, showing that in all probability this fair weather would not continue, advantage was taken of it and a sounding and trawling were obtained, the depth being 1975 fathoms, Diatom ooze, Station 156 (see Sheet 23). At noon the position of the ship was lat. 62° 26′ S., long. 95° 44′ E., and there were thirty icebergs in sight, but no pack ice.

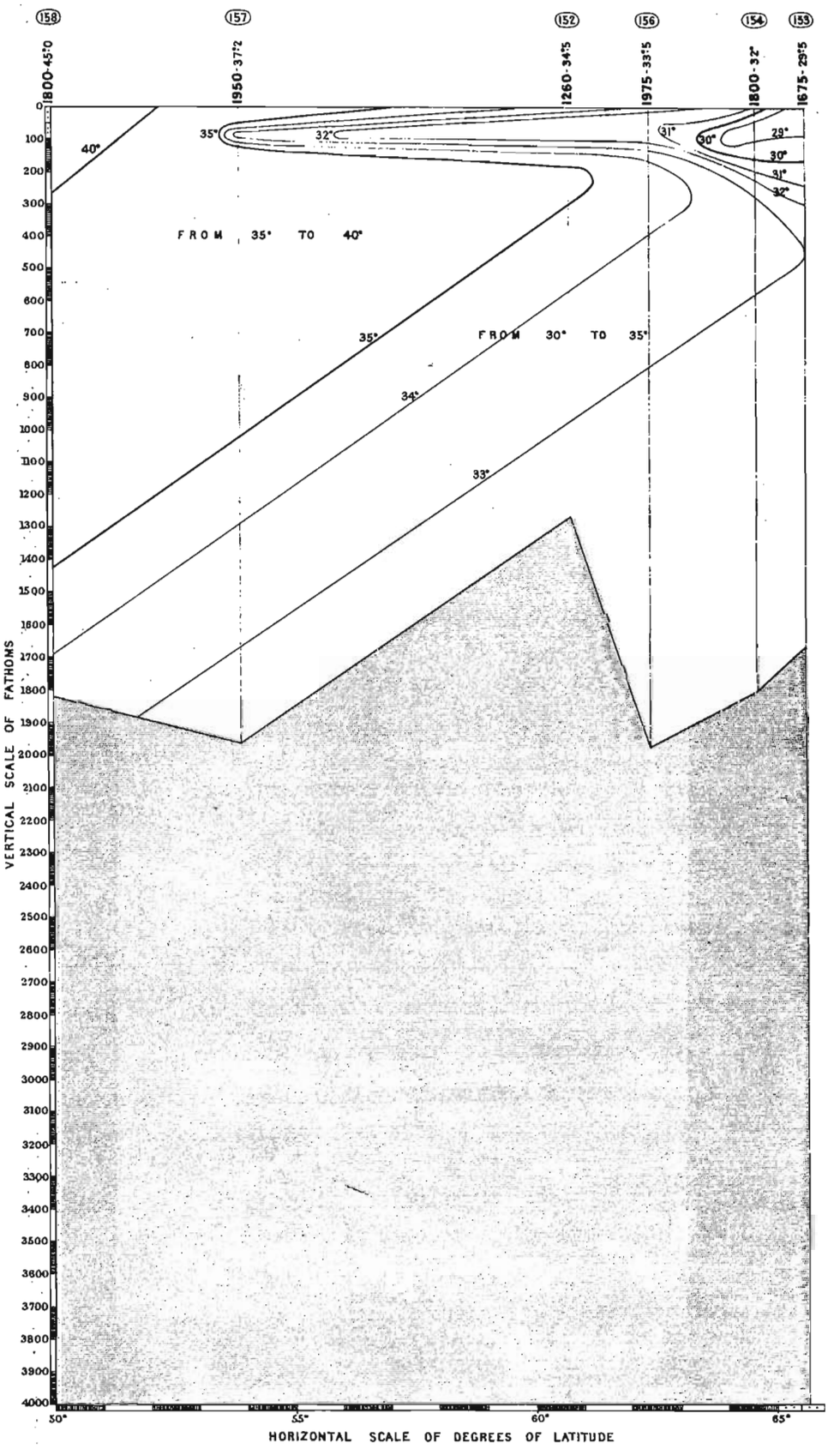
The same difficulty was experienced in obtaining serial temperatures as before, although the thermometers were cooled by a mixture of ice and salt before immersion. The surface temperature was 33°, the temperature at 100 fathoms 31°·9, at 150 fathoms 34°, and below the depth of 150 fathoms the thermometer came up showing on the maximum side 34° and on the minimum 31°·9, hence it is impossible to say what the precise temperature of the sea was below 150 fathoms; all that can be asserted is that it ranges between 34° and 31°·9. It is true the bottom thermometer showed 34° on the maximum side and 31°·3 on the minimum, but as it was cooled before

SOUTHERN INDIAN OCEAN

Meridional Temperature Section

Between the Parallels of 50° and 65° South Lat.

For explanation of Symbols see Appendix 1.



Engraved by Malby & Sons

immersion, and, unfortunately, the height of the indices was not noted, it is not certain that it did not stand at 31°·3 before it entered the water. At 4 P.M. the weather, which had been hitherto fine, began to look threatening, and the barometer, which at noon stood at 29·182 inches, had fallen slightly, so after heaving in the trawl, sail was made to double-reefed topsails and courses on the starboard tack, the wind being N. (true), as it was expected to shift to the eastward; forty icebergs were counted from the deck at 4.30 P.M., but shortly afterwards snow began to fall, limiting the vision to a quarter of a mile, and necessitating getting steam up in three boilers ready for all emergencies. At 6.30 P.M., during a decrease in the snowfall, a very large iceberg was seen to windward, and so the ship worked up towards it under steam and sail, and when under its lee sails were furled for the night, the officers being as thankful to get behind this friendly breakwater as one sometimes is to get into harbour. The wind rapidly increased to force 9 by 8 P.M., and the barometer still falling, steam was raised in the fourth boiler in order to maintain the position under the lee of the berg. The night was an anxious one, but not so bad as that of the 24th February, as the wind was never so strong as to prevent the ship facing it, and it was only necessary to use full steam on one occasion. The wind blew in fierce gusts over the top of the berg, alternating with periods of almost calm, rendering it necessary to use great caution in the power of steam, which had to be constantly varied as the wind changed in force, giving the officer in the engine-room considerable trouble. After 8 P.M. the snow was succeeded by rain and a partial thaw for a time, the temperature rising to 35°. At 11 P.M. the barometer reached its lowest point, 28·785 inches.

On the 27th February, at 3 A.M. (daylight), the vessel left the friendly breakwater, the iceberg, and made sail to close-reefed topsails and foresail, steering to the northward, the wind N.W. by W. (true), force 9. At 8 A.M. the wind had moderated sufficiently to allow two reefs to be shaken out and reefed mainsail set, and at noon the force was 6 to 7, the ship being under single reefs and top-gallant sails. The average velocity of the wind at 8 A.M. was 28 miles per hour, during the forenoon 25, and in the afternoon 22; that is without allowing anything for the speed of the ship through the water, as the wind was nearly on the beam. The limit of vision during the day was about four miles. Numerous bergs were passed as the ship ran to the northward seven or eight miles per hour, but few were visible at any one time owing to the misty state of the weather. It was fortunate that this gale did not shift to the east and south, as had it done so all the ropes and blocks would have been frozen together after the sludgy snow that fell during the night. After experiencing two heavy gales whilst surrounded by icebergs, one can readily realise the great dangers which a sailing vessel must encounter in navigating these seas, and can to a certain extent appreciate the feelings of the purser of Wilkes' ship, who, when called upon for his written opinion as to the expediency of prosecuting their researches further south, immediately after they had successfully battled against weather somewhat similar to that experienced in the Challenger during the last

few days, answered that he failed to see the utility of proceeding when there was so great a probability of no one living to carry home the tale. At 8 P.M. sail was shortened to double-reefed topsails, and the ship continued working for the night between two icebergs separated from each other five or six miles, the space between them being free from danger. A fresh breeze blew all day, with a cloudy sky, the barometer rising slightly, its mean height 28·940 inches, and the mean temperature of the air 34°·1, of the sea surface 33°·7. The position at noon, lat. 62° 2′ S., long. 97° 6′ E.

On the 28th, at 3 A.M., sail was made and the northerly course resumed; numerous icebergs were passed, the greatest number in sight at any one time being twenty-four. At 5.30 P.M. sail was shortened to triple-reefed topsails and courses. At 8 P.M. the courses were taken in, and it being moonlight the ship proceeded under easy sail until 11.30 P.M., and then laid to for the night. There was a strong breeze all day, with a westerly swell, the barometer rising from 29·076 to 29·335 inches at 10 A.M. and falling to 29·195 inches at midnight; the weather was clear in the morning, but cloudy and gloomy, with snow showers during the rest of the day. A strong northerly current was observed. Mean temperature of the air 34°·6, and of the surface water 34°·4; position at noon, lat. 59° 56′ S., long. 99° 14′ E.

On Sunday, March 1st, 1874, at 3.30 A.M., sail was made and the course resumed towards Melbourne. Between 4 and 8 A.M. four icebergs were seen, but at noon no ice was in sight, the position being lat. 58° 5′ S., long. 101° 56′ E. At 4 P.M. one berg was seen to the northwestward (true), distant four or five miles. At 8 P.M. and midnight no ice was in sight. The ice having decreased so rapidly, it was not considered necessary to shorten sail and heave to during any part of the night, more especially as by the aid of the moon objects could be seen at a distance of three quarters of a mile distinctly. The wind was fresh all day, force 8 at 1 A.M., moderating gradually to force 5 by midnight, the weather being thick and gloomy, the sky covered with an impervious cloud, a moderate westerly swell. Barometer rising from 29·149 to 29·520 inches, mean temperature of the air 36°·2, of the surface water 35°·1.

On the 2nd, at 3 A.M., the ship passed close to a large iceberg and the course had to be altered to clear it; this was the only one seen throughout the day. The wind continued fresh up to 4 P.M., after which it shifted to the southwestward and died away; the weather continued cloudy and gloomy till 6 P.M.; the barometer rising steadily from 29·530 to 29·948 inches; the mean temperature of the air 38°·2, of the surface water 37°·5; the position at noon, lat. 55° 38′ S., long. 106° 10′ E.

On the 3rd, the wind being light and the sea moderate, a sounding, trawling, and temperatures were obtained in 1950 fathoms, Diatom ooze, Station 157 (see Sheet 24). The serial temperatures obtained showed that, from the surface to the depth of 60 fathoms, the water remained at 36°·6, but at 70 fathoms it had cooled to 33°, and at 80 fathoms to 32°·5. Below that depth the temperature could not be ascertained with

SHEET 24

FROM A POSITION IN

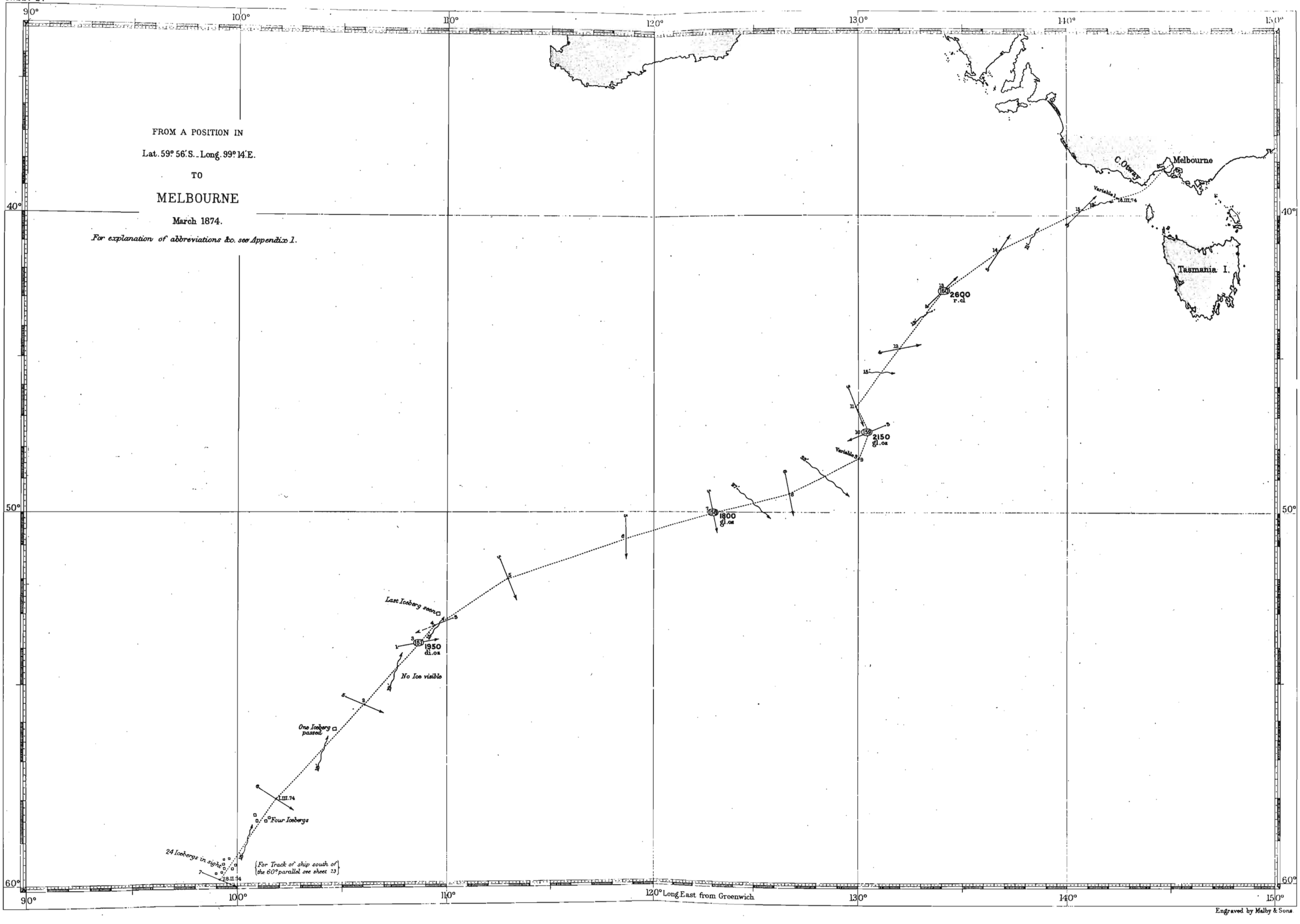
Lat. 59° 56'S. - Long. 99° 14'E.

TO

MELBOURNE

March 1874.

For explanation of abbreviations &c. see Appendix 1.



Engraved by Malby & Sons

precision, as the thermometers when brought to the surface showed, with one exception, the same temperature on the maximum side as on immersion, and on the minimum side the same as at 80 fathoms. The bottom thermometer gave a result of 32°, which is probably the bottom temperature, being slightly colder than the results above that depth. Whether this be so or not, it is at any rate certain that the bottom temperature was not below 32°. At 4 P.M., after heaving in the trawl, sail was made. The day was fine, but cloudy, the wind gradually falling until at 6 P.M. it was quite calm, the barometer steady at 30·045 inches, the mean temperature of air 36°·9, of sea surface 37°·5, the sea smooth; the position of the ship at noon, lat. 53° 55′ S., long. 108° 35′ E. No ice of any description was seen during the day. At 11.45 P.M. a brilliant aurora was observed stretching in four concentric arcs from E.S.E. to W.S.W. between the zenith and an altitude of 30°.

On the 4th a southeasterly breeze sprang up, and shifted gradually to the northeast and north, freshening towards midnight. The weather was fine in the morning and forenoon, but cloudy in the afternoon, and misty and foggy in the evening. The barometer steady at 30·053 inches, but inclined to fall; mean temperature of the air 38°·6, and of the surface water 38°·9. At noon an iceberg was seen to the northward, and it was passed at 6 P.M. This proved to be the last berg seen on the voyage, and it was evidently fast breaking up, being a round-backed piece of ice, in shape somewhat like a capsized vessel, and not much larger.

On the 5th and 6th March a steady northerly breeze was experienced, mean force 5, with a smooth sea, and a southwesterly swell, the barometer fairly steady, the temperature both of air and sea increasing.

On the 7th a sounding, trawling, and temperatures were again obtained, the depth being 1800 fathoms, Station 158 (see Sheet 24). It was found that the nature of the bottom had changed from Diatom ooze to Globigerina ooze. The serial temperature sounding showed that, at this position, lat. 50° 1′ S., long. 123° 4′ E., the temperature of the sea decreased gradually from the surface to the bottom, or from 45° to 33°·5, as is generally the case (see Diagram 10). The ship had therefore now got to the northward of the peculiar condition as regards temperature of the sea in the Antarctic basin. The weather during the day was fine, but cloudy, and occasionally misty. The wind still steady in direction (N. true), but increasing in force towards midnight; the barometer falling somewhat, the mean temperature of the air 47°·4, of the sea surface 45°·3.

On the 8th the northerly wind still continued, force 6, with fine weather and smooth water, barometer fairly steady at 29·831 inches. Mean temperature of the air 50°·2, of sea surface 48°·8. The velocity of the wind by the anemometer was 23 miles per hour. At midnight the patent log when hauled in was found entangled in a large piece of kelp covered with barnacles. As the vessel was then in the parallel of Kerguelen, and there is no kelp at Heard Island, it is probable that this weed may have drifted from

Kerguelen. Three strata of clouds were noticed during the day, the upper stationary, the middle floating from the northwest, and the lower from the north.

On the 9th, the northerly wind gradually decreased, until at noon it was nearly calm. Shortly after a slight southeast wind sprang up, the sea being smooth, the weather cloudy in the forenoon, but fairly clear in the afternoon, the barometer steady at 29·887 inches; mean temperature of the air 51°·2, of the surface water 50°·6; position at noon, lat. 58° 18′ S., long. 130° 4′ E.

On the 10th, the wind continuing light from the eastward, the barometer falling, the weather dark, gloomy, and misty, advantage was taken of the smooth sea and the light breeze to sound, trawl, and obtain temperatures. The depth was 2150 fathoms, Globigerina ooze; bottom temperature 34°·5, Station 159 (see Sheet 24). The trawl when hove to the surface contained some shrimps and fishes, but apparently had not reached the bottom. One of the fishes belonged to a new genus, thus described by Dr Günther:—

Echiostoma.—"The fishes of the family Stomiatidæ, to which this genus belongs, are armed with formidable teeth, a certain indication of their voracity and predaceous habits.

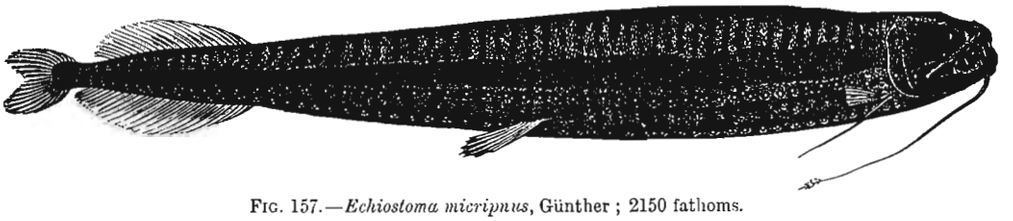


Fig. 157.—*Echiostoma micripnus*, Günther; 2150 fathoms.

Their elongate body is covered with a smooth, scaleless skin of an intensely black colour. The vertical fins are close together, near the end of the tail, as in the pike, forming a powerful propeller, by a single stroke of which these fishes are enabled to dart with great rapidity to a considerable distance. A long filament is suspended from below the chin, and, as it is frequently fringed at its extremity, it evidently serves as a lure for other fishes or animalculæ. Series of luminous globular bodies run along the lower half of the body and tail, and some others of larger size occupy the side of the head, generally below the eye or behind the maxillary bone. The species figured has, besides, the lower pectoral ray prolonged and detached; it probably acts as an organ of touch."

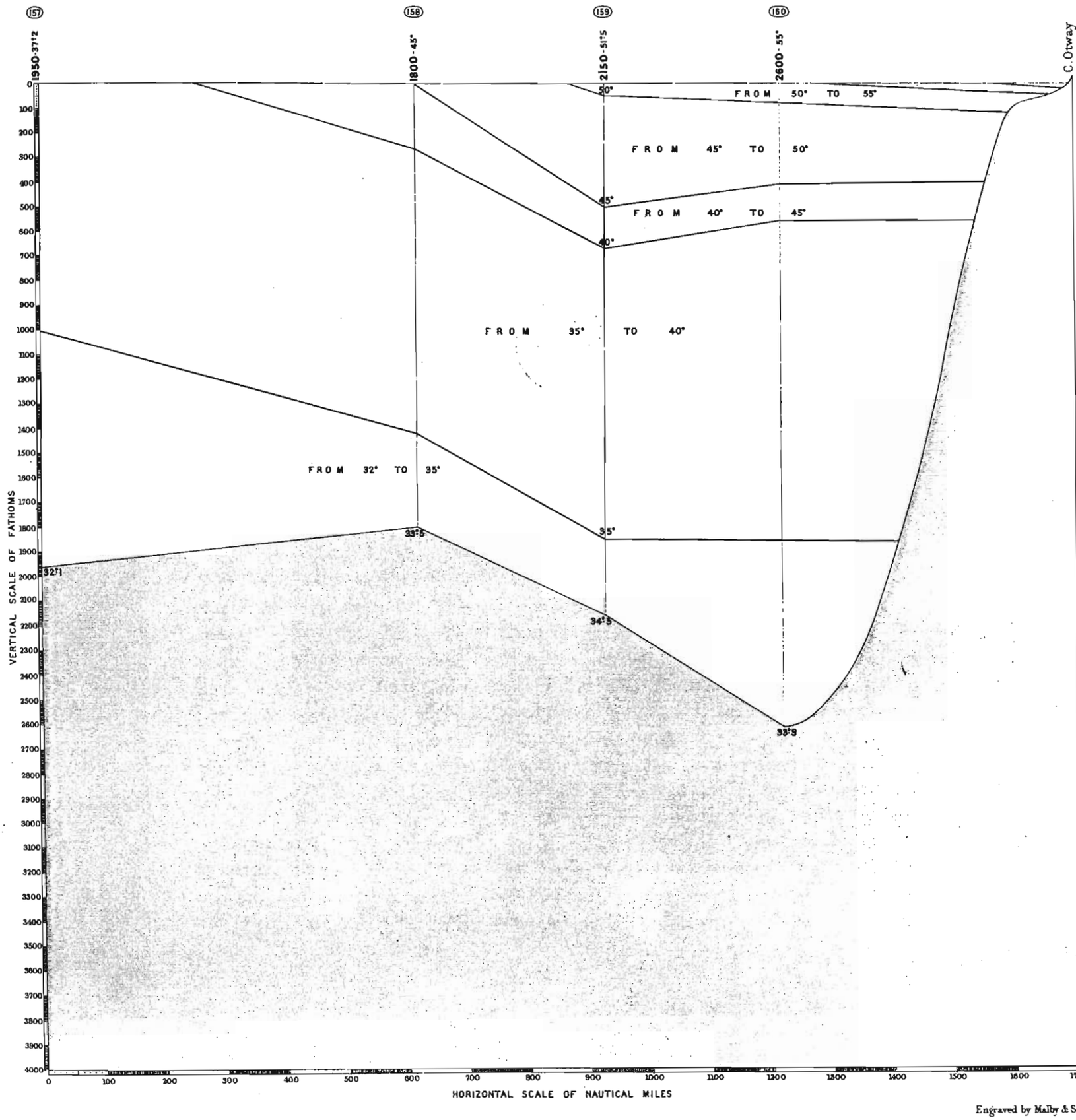
The specimen was 16 inches in length. The end of the barbel, which was thickened, was flesh-colour with a rose tint; there was also a rose tint on the dorsal and anal fins. The rest of the animal was of a dark colour with a perceptible slate-coloured tint. The phosphorescent spots along the belly and radial and lateral line were red, as was also that below the eye.

At 4 P.M. sail was made to double-reefed topsails and courses in anticipation of a gale; the wind was easterly working to the northward, force 4; drizzly, misty weather;

SOUTHERN INDIAN OCEAN

Diagonal Temperature Section . From a Position in Lat. 53°55′S.. Long. 108°35′E. to C. Otway.

For explanation of Symbols see Appendix 1.



Engraved by Malby & So

barometer 29·871, at 1 A.M., falling to 29·449 inches at midnight; mean temperature of air 51°·2, of sea surface 51°·2.

On the 11th, the barometer reached its lowest point at 6 A.M. (29·316 inches). At 8 A.M. the wind shifted to northwest, and the mercury began to rise and continued its upward movement for the remainder of the day, but the change of wind and rising barometer brought no corresponding change in the weather, which continued gloomy and misty with drizzling rain. The sun broke through the clouds for a minute or two at 9 A.M. and 11 A.M., so that the position could be ascertained astronomically, which was at noon, lat. 46° 37′ S., long. 129° 56′ E.; the mean temperature of the air 52°·7, of the sea surface 51°·7.

On the 12th, at 7 A.M., the wind shifted to the southwestward, the mist gradually lifted, and it was, comparatively speaking, a fine day with a steady breeze, force 4; the barometer rose slowly and steadily to 29·700 inches, the mean temperature of the air 51°·3, of the sea surface 53°·1.

On the 13th a sounding, trawling, and temperatures were obtained in lat. 42° 42′ S., long. 134° 10′ E., the depth being 2600 fathoms, red clay, bottom temperature 33°·9, Station 160 (see Sheet 24). The trawl caught at the bottom occasionally, and had to be hove up carefully; it was much torn when it arrived at the surface, but fortunately the cod was whole, and contained a number of manganese nodules. At 6 P.M. sail was made and the ship stood on for Melbourne. The weather during the day was fairly fine, with occasional passing showers of drizzle, the wind southwest; the barometer steady at 29·741 inches; the mean temperature of the air 51°·6, of the sea surface 55°; the atmosphere drier than any experienced since leaving Kerguelen with one exception.

On the 14th the weather was fine, with the wind steady in force, though not in direction, veering between south and southwest; the barometer rising slowly, mean temperature of air 52°·9, of sea surface 57°·8.

On the 15th the weather was fine with a light southwest wind and rising barometer; and the air thoroughly dried the decks, the first time for six weeks. At 4 P.M. a vessel was seen to the northward, which, with the exception of the schooners at Kerguelen, was the only ship seen since leaving the Cape of Good Hope.

On the 16th, the wind falling light, and the barometer having risen slowly and steadily to 30·205 inches, which, combined with the fine settled look of the weather, indicated a continuance of the calm, steam was got up and the vessel proceeded towards Cape Otway. At noon the high land to the northward of that Cape was observed, and at 5 P.M. the Cape itself. At 8 P.M. Cape Otway was passed and the course altered for Melbourne. The weather was fine, and the atmosphere remarkably clear, Mount Sabine having been seen at 60 miles distance; the mean temperature of the air 58°·6, of the sea surface 61°·2.

On the 17th, at daylight, the whole of the land in the vicinity of Port Philip was distinctly visible. A high saddle peak was noticed north of Geelong, no mention of which is made in the sailing directions; probably it is not often seen, for the atmosphere was remarkably clear; the ship passed the Narrows at 8 A.M., and was moored in Hobson's Bay at 2 P.M.