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THE GUT OF NEBALIACEA

By

HELEN G. Q. ROWETT

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THE GUT OF NEBALIACEA

By Helen G. Q. Rowett, Grisedale Scholar, Manchester University

INTRODUCTION

Much attention has been paid by Cannon, Manton, Lowndes and others to the 'feeding mechanisms' of Crustacea, but no attempt has so far been made to correlate changes in the structure of the gut with the type of food available and the condition in which it is passed into the mouth. For this purpose it is necessary to compare members of one group which have different habits and habitats rather than isolated examples from different groups. A survey of the Nebaliacea has therefore been made with the object of discovering how far the structure of the gut shows group resemblances and how far it may be associated with the environment and habits of the species concerned.

METHODS

With the exception of *Nebalia bipes*, material for this investigation was limited to Discovery specimens of *Nebaliopsis typica* and *Nebaliella extrema* kindly made available by Professor Cannon.

Reconstructions were made using transverse sections of *Nebaliopsis typica* specimen E (*Discovery Reports*, 1931, vol. III) and sagittal sections of half of specimen F2 (op. cit.) and the unsectioned other half of this specimen. From these reconstructions Figs. 4, 5, 6 C and 7 A were made.

The single specimen of *Nebaliella extrema* was sectioned transversely, and the reconstructions shown in Figs. 2, 3, 6 B and 7 C were obtained.

Besides sectioned material the cast skins of *Nebalia bipes* were examined and living specimens were watched in a jar with sea water and some of the mud from their usual habitat in Rum Bay, Plymouth, and also isolated in dishes under a microscope. Carmine was fed to some and, using strong illumination, the passage of the red particles through the gut was easily seen through the semitransparent body.

THE STRUCTURE OF THE GUT OF *NEBALIA BIPES* (Fabricius)

The structure of the gut of *Nebalia* was described in great detail by Claus (1889) and later by Jordan (1909, 1912) in papers comparing the pyloric section with that of *Idothea*, *Gammarus* and *Astacus*. A detailed description need not, therefore, be given here, but for the sake of clarity in making comparisons with other types Figs. 1, 6 A and 7 B have been made which show the various parts and associated musculature.

In one important respect, however (which is not mentioned by Jordan), Claus's description is definitely incorrect. The structures which he describes as chitinous pads with thickened striations are actually rows of very strong evenly set setae ($g.s._1$ in Fig. 1) which with the spines ($g.s._2$) form a tube in which grinding takes place.

THE STRUCTURE OF THE GUT OF *NEBALIELLA EXTREMA* (f. Thiele)

I. FORE-GUT

The structure of the oesophagus and cardiac region of the stomach of *N. extrema* is, as Thiele (1905) says, very like that of *Nebalia*. Certain important differences may, however, be noted.

There are many fewer setae throughout. The anterior median projection (*a.m.p.*) is much reduced and the lateral fanlike plate of setae which is found on the right side only in *Nebalia* (*l.p.* Fig. 1) is absent. The spatial relations of the homologous parts are so altered that there is no grinding tube such as is seen in *Nebalia*. As shown in Figs. 2 and 3 A, the spines ($g.s._2$) are ventral instead of dorsal

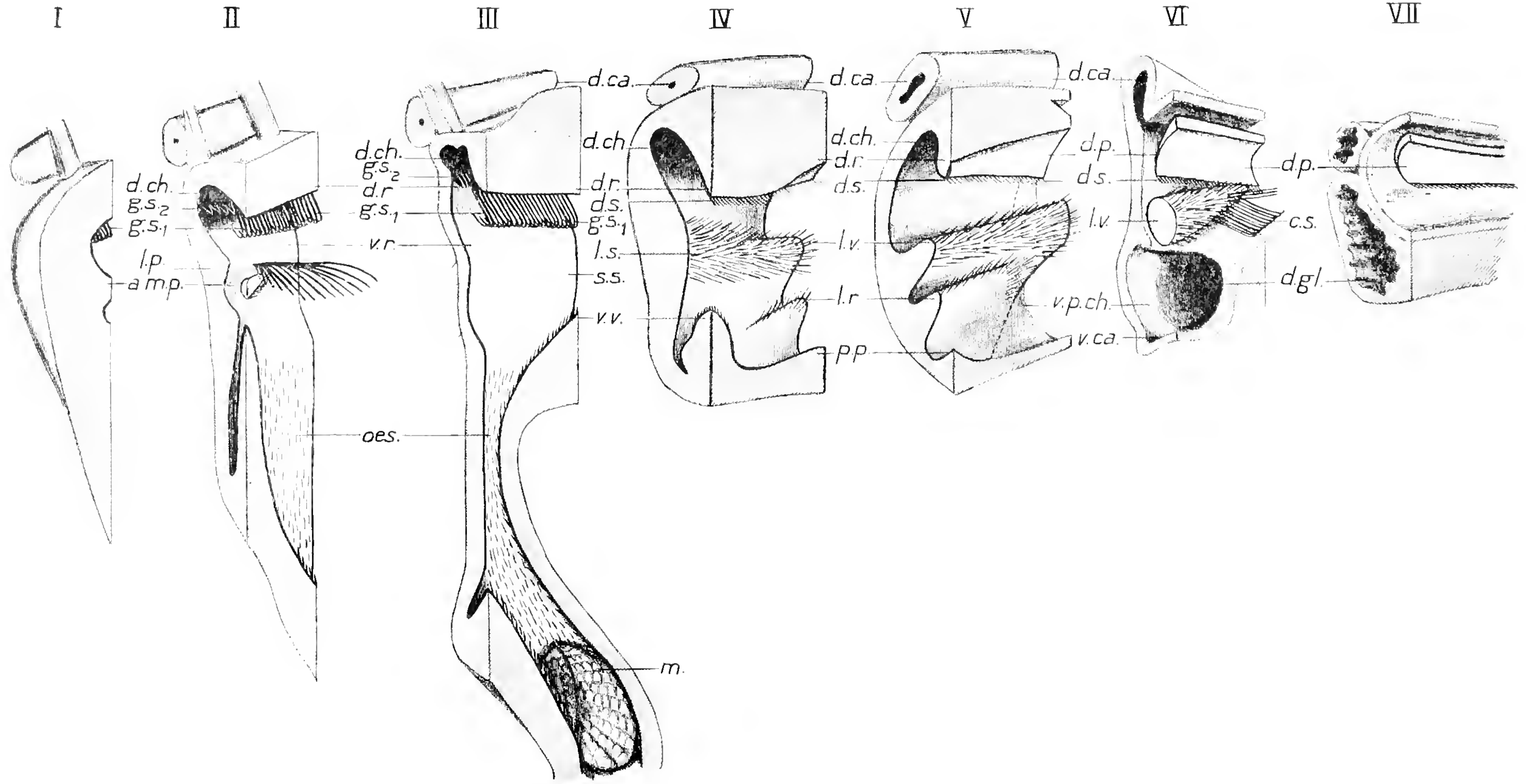


Fig. 1. Diagrammatic reconstruction of the fore-gut of *Nebalia bipes* in seven sections (I–VII). *a.m.p.* anterior median projection; *c.s.* comb of setae at the mouth of the intestine; *d.ca.* dorsal caeca; *d.ch.* dorsal channel; *d.gl.* digestive glands; *d.p.* dorsal process; *d.r.* dorsal ridge; *d.s.* setae on the dorsal process; *g.s.*$_1$ strong setae; *g.s.*$_2$ short stiff spines; *l.p.* lateral fanlike plate of setae; *l.r.* lateral ridge; *l.s.* long setae on the lateral walls in the pyloric region; *l.v.* lateral fingerlike process; *m.* mandible; *oes.* oesophagus; *p.p.* pyloric pad; *s.s.* very short fine setae on the lateral walls in the cardiac region; *v.ca.* ventral caeca; *v.p.ch.* ventral pyloric chamber; *v.r.* vertical ridges; *v.v.* ventral cardio-pyloric valve.

to the regular row of setae (*g.s.*$_1$). Of equivalent functional significance is the grinding organ formed by the setae alone (*g.s.*$_1$), which slope diagonally backwards and outwards almost parallel to, and rubbing against, a slightly setose horizontal shelf of each lateral wall. The more anterior of these grinding setae are longer than the posterior ones, their tips curve upwards and a pair of small ridges (*d.r.'*) lie medial to the basal thickening on which they are inserted.

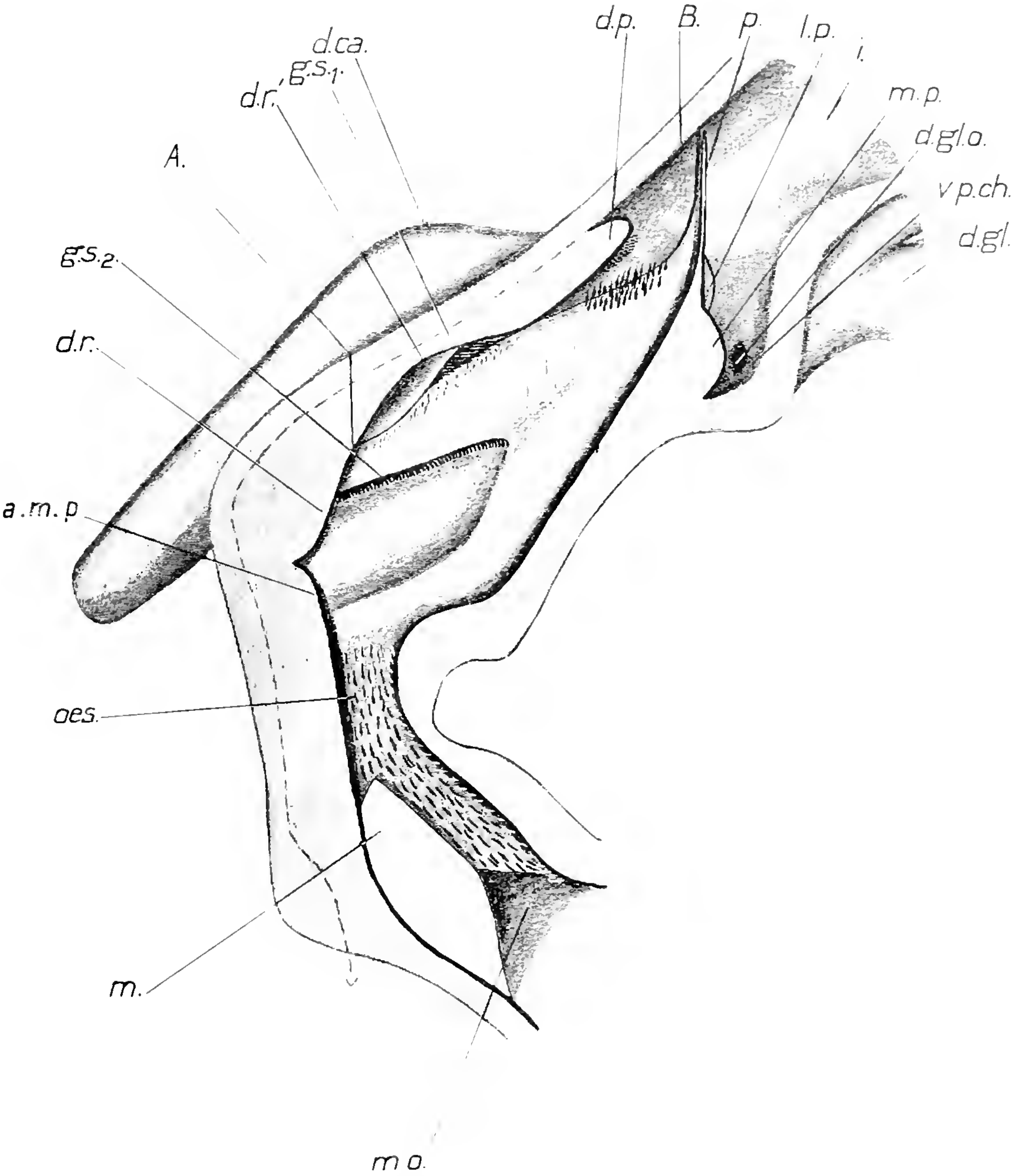
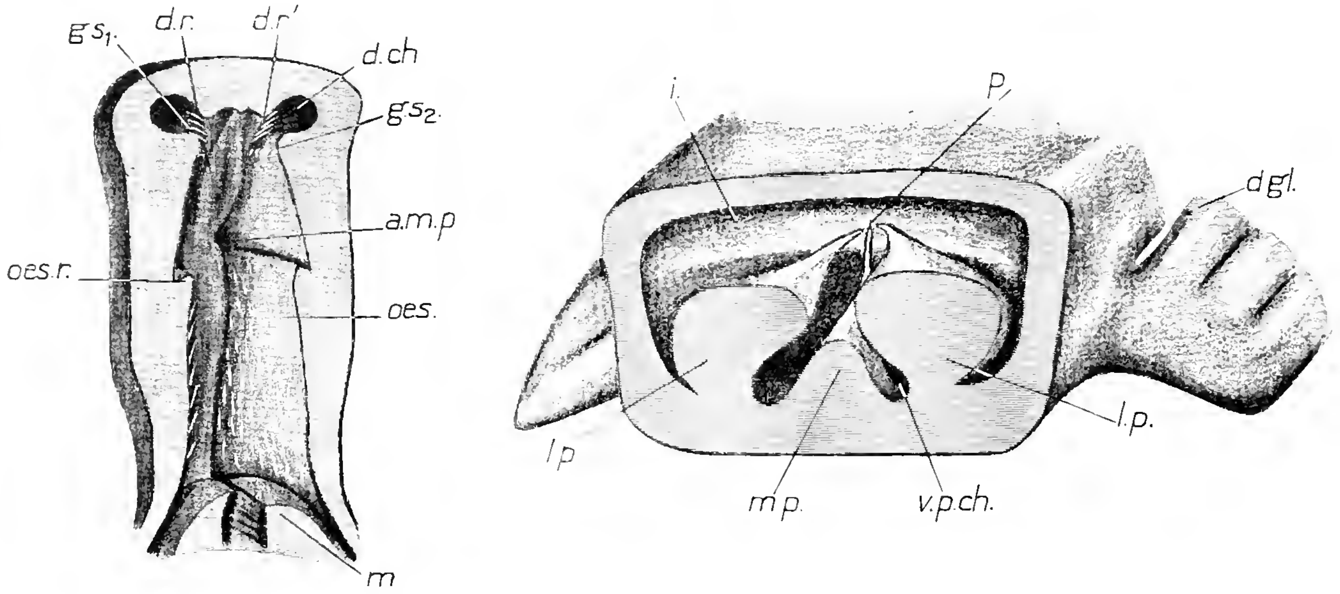


Fig. 2. Diagram of the right half of the fore-gut of *Nebaliella extrema*. A, region at which Fig. 3 A was cut; B, region at which Fig. 3 B was cut. *a.m.p.* anterior median projection; *d.ca.* dorsal caecum; *d.gl.* digestive glands; *d.gl.o.* opening of the digestive glands; *d.p.* dorsal process; *d.r.* dorsal ridge; *d.r.'* small ridge on the dorsal ridge; *g.s.*$_1$ strong setae; *g.s.*$_2$ short stiff spines; *i.* intestine; *l.p.* lateral pad; *m.* mandible; *mo.* mouth; *m.p.* median pad; *oes.* oesophagus; *p.* long projections; *v.p.ch.* ventral pyloric chamber with opening of the digestive glands; ------ outline of the lumen of the gut laterally.

Ventral to the row of spines (*g.s.*$_2$) is a slight ridge on each lateral wall behind which is a strong contractor muscle. This ridge marks the division between the oesophagus and the stomach.

There is no distinct division into cardiac and pyloric regions, but, posteriorly, where the spines (*g.s.*$_2$) and setae (*g.s.*$_1$) cease, the lateral walls approach one another more closely and their surfaces are soft and irregularly corrugated. In this region the dorsal glandular caeca (*d.ca.*) open into the dorso-lateral angles of the lumen. Slightly posterior to these openings the dorsal ridge (*d.r.*) becomes free from the dorsal wall and projects a short distance as a soft pad (*d.p.*). Similarly swellings of the lateral and ventral walls split off together from the gut walls and form a trilobed chitin-covered process (*l.p.* and *m.p.*), each of whose lobes bears a long projection (*p.*) converging dorsally as shown in Fig. 3 B.

The lateral lobes bear strong setae and are undoubtedly homologous with the lateral finger-like processes of *Nebalia*, but the homologies of the median ventral lobe are uncertain. Thiele suggests that it may be the sum of the two lateral ridges (*l.r.*) of *Nebalia*. If this were the case it might be expected that some trace of the double nature would remain, but none could be found. It is more likely that it is homologous with the ventral cardio-pyloric valve, the shifting of which posteriorly is a slight change comparable with the other differences between the two species. A third alternative is that the small pyloric pad of *Nebalia* (*p.p.* Fig. 1) has been greatly enlarged, but this, like Thiele's suggestion, is a major alteration involving the disappearance of the cardio-pyloric valve.



A B

Fig. 3. A. Anterior region of the fore-gut of *Nebaliella* looking forwards into a piece cut at region A of Fig. 2 to show the relationships of the parts hidden by the median structures. *a.m.p.* anterior median projection; *d.ch.* dorsal channel; *d.r.* dorsal ridge; *d.r.'* small ridge on dorsal ridge; *g.s.*$_1$ strong setae; *g.s.*$_2$ short stiff spines; *m.* mandible; *oes.* oesophagus; *oes.r.* oesophageal ridges. B. Posterior region of the fore-gut and the entrance to the intestine of *Nebaliella* looking backwards from region B of Fig. 2 to show the spatial relations of the pads and the projections thereon in the pyloric part of the gut. *d.gl.* digestive glands; *i.* intestine; *l.p.* lateral pad; *m.p.* median pad; *p.* long projections; *v.p.ch.* ventral pyloric chamber.

II. MID- AND HIND-GUT

Besides the dorsal glandular caeca already mentioned, *Nebaliella* resembles *Nebalia* in having three digestive gland caeca (*d.gl.*) on either side. These unite and open into the ventro-lateral corners of the ventral pyloric chamber (*v.p.ch.*) immediately posterior to the tripartite process. The openings are smaller than those in *Nebalia*. Ventral glandular caeca were not found.

The lumen of the intestine is relatively wider than in *Nebalia*, and for a considerable distance is roughly triangular, with one angle dorsal and two ventro-lateral, and with walls of highly vacuolated cells. Passing posteriorly the cells become less vacuolated and a striated border appears on them. Then the outline of the gut becomes oval and the striated border deeper. Finally the cross-section is almost circular, the cells are very dense and closely packed together, and some are elongated and project as ridges into the lumen.

As in *Nebalia* the intestine and digestive glands are embedded together in a loose tissue of highly vacuolated cells.

There is a very much reduced rectal gland and an anal chamber comparable to these structures in *Nebalia*.

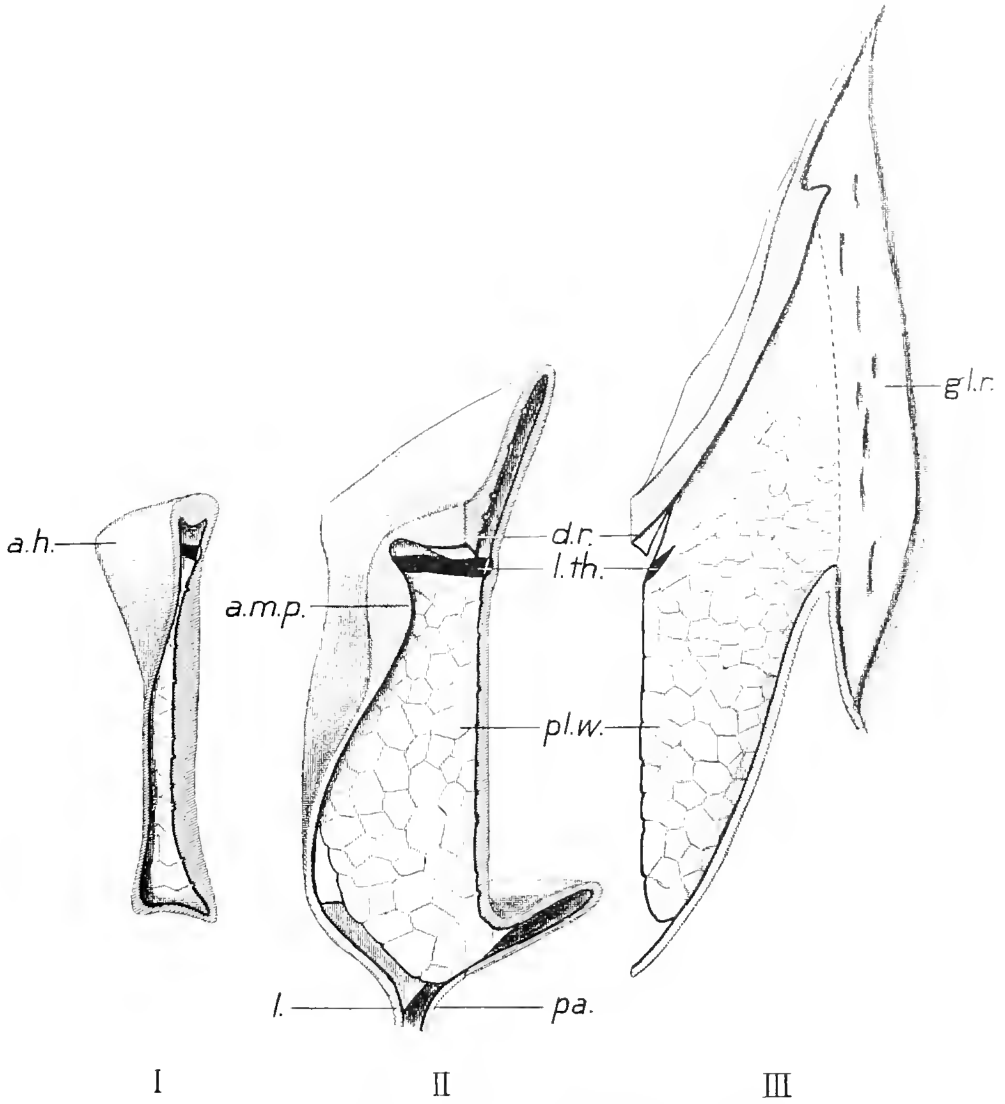


Fig. 4. Diagrammatic reconstruction of the right half of the fore-gut of *Nebaliopsis typica* in three sections (I–III). *a.h.* anterior horn; *a.m.p.* anterior median projection; *d.r.* dorsal ridge; *gl.r.* glandular region; *l.* labrum; *l.th.* lateral thickenings; *pa.* paragnaths; *pl.w.* plated walls.

MUSCULATURE

The similarities between the musculature of the fore-gut of *Nebaliella* and that of *Nebalia* are very striking, as the diagrams (Figs. 6 A, B) show. Differences are that the lateral dilator muscles (*l.dil.*) of the oesophagus have five points of insertion as compared with two in *Nebalia*. The muscle corresponding to the small median projection muscle is greatly enlarged. The anterior dorsal dilators (*a.d.dil.*) are also enlarged but the posterior dorsal dilators (*p.d.dil.*) are reduced, though there is a great thickening of the chitin at their point of insertion. The strong circular muscle (*cont.*) which is so conspicuous in *Nebalia* is present in *Nebaliella* also, though slightly reduced. No muscles could be found in the groove between the anterior horns of the stomach where *Nebalia* has a few thin strands of fibres.

In addition to these muscles which have their homologues in *Nebalia*, *Nebaliella* has a pair of very strong muscles (*t.p.m.*) which stretch ventro-laterally from a thickening of the chitin of each lateral lobe of the trilobed process immediately anterior to the point where the process splits from the gut wall.

THE STRUCTURE OF THE GUT OF *NEBALIOPSIS TYPICA* (Sars)

FORE-GUT

The external features of *Nebaliopsis* (Cannon, 1931, pl. xxxii) indicate that it is a highly specialized member of the Nebaliacea, and this is confirmed by the internal organization. Even in the gastric mill group resemblances are few.

Fig. 4 shows the reconstruction of the right half of the fore-gut in three sections.

The molar processes of the mandibles are reduced and do not project into the mouth as in the other forms. The mouth is a transverse slit between the labrum (*l.*) and the paragnaths (*pa.*). These can be retracted by strong muscles, thus uncovering a flat plate of chitin with a median antero-posteriorly directed slit leading into the stomach. The latter slit can be opened widely by the dilator muscles (*l.dil.*), which slope upwards and outwards from the oesophageal wall. Very great variation of both the size and the shape of the gape is thus possible by the combined action of these two slits.

There is no distinct separation into oesophagus, cardiac and pyloric parts, but the region surrounded by the horizontal circular muscles, and to which the lateral dilators are attached, may be considered oesophageal in comparison with *Nebalia*.

Setae are entirely absent from the gut. Except in the most anterior and dorsal regions the chitinous lining of the lateral walls has the appearance of crazy-paving owing to the presence of grooves over the junctions between the individual cells of the supporting tissue (Fig. 5 C, D). Posteriorly these grooves are less distinct. The paved parts of the walls lie very close together (Fig. 5 C) and provide a good gripping surface.

An anterior median projection (*a.m.p.*) is present as in *Nebalia*, but much reduced. There is a dorsal ridge (*d.r.*) which is strongly chitinized and slightly grooved in the region immediately dorsal to the mouth, but it arises anteriorly as a soft pad and becomes so again posteriorly. The lateral walls have thickenings (*l.th.*) against which this ridge bites. The thickenings of the chitin are prolonged into short anterior projections of the stomach, and may be homologous with the slight thickenings at the bases of the spines ($g.s._2$) in *Nebalia*. There are no grinding tubes, but a strong grinding or biting action probably occurs between these heavily chitinized regions.

Posteriorly where the dorsal ridge becomes a soft pad, the side walls open out slightly and they also become soft. The chitinous lining of the fore-gut ends raggedly; the walls become glandular and lose the thick muscle sheath which encircles them throughout the stomach region.

MID- AND HIND-GUT

The glandular region mentioned above marks the beginning of the mid-gut. Here the anterior digestive diverticula (*d.gl.*), which are comparatively small (Fig. 6 C), and extend only a short distance forwards and which are probably homologous with the dorsal caeca of *Nebalia*, open by irregular apertures. Some of these are small channels passing through the glandular region, but the largest opens below a flap (*gl.r.* in Fig. 4) directly into an immense digestive sac (*d.s.* in Fig. 7 A), which widens out suddenly and almost completely fills the body cavity back to the end of the fourth abdominal segment, and which may be homologous with the digestive caeca of *Nebalia*, though it is difficult to be certain of any homologies when the specialization is so great. It is important to note that this is a plain sac without any convolutions and with only a few thin septa rising from its walls. The enlargement therefore does not provide a great deal of extra surface area for absorption, but it does give a large volume for storage. The walls of the sac are formed of a thin layer of pavement epithelium made up of huge highly vacuolated cells with a striated border and an average diameter of 0·1 mm. (Fig. 5 A, B). A very thin basement membrane lies behind them.

The intestine is a very narrow tube lying dorsal to this sac (Fig. 7 A). In places the lumen is so small that it is hardly distinguishable, but posterior to the end of the digestive sac it opens out into a wider rectal region. A muscular sphincter separates it from a short proctodeum. No rectal gland was found.

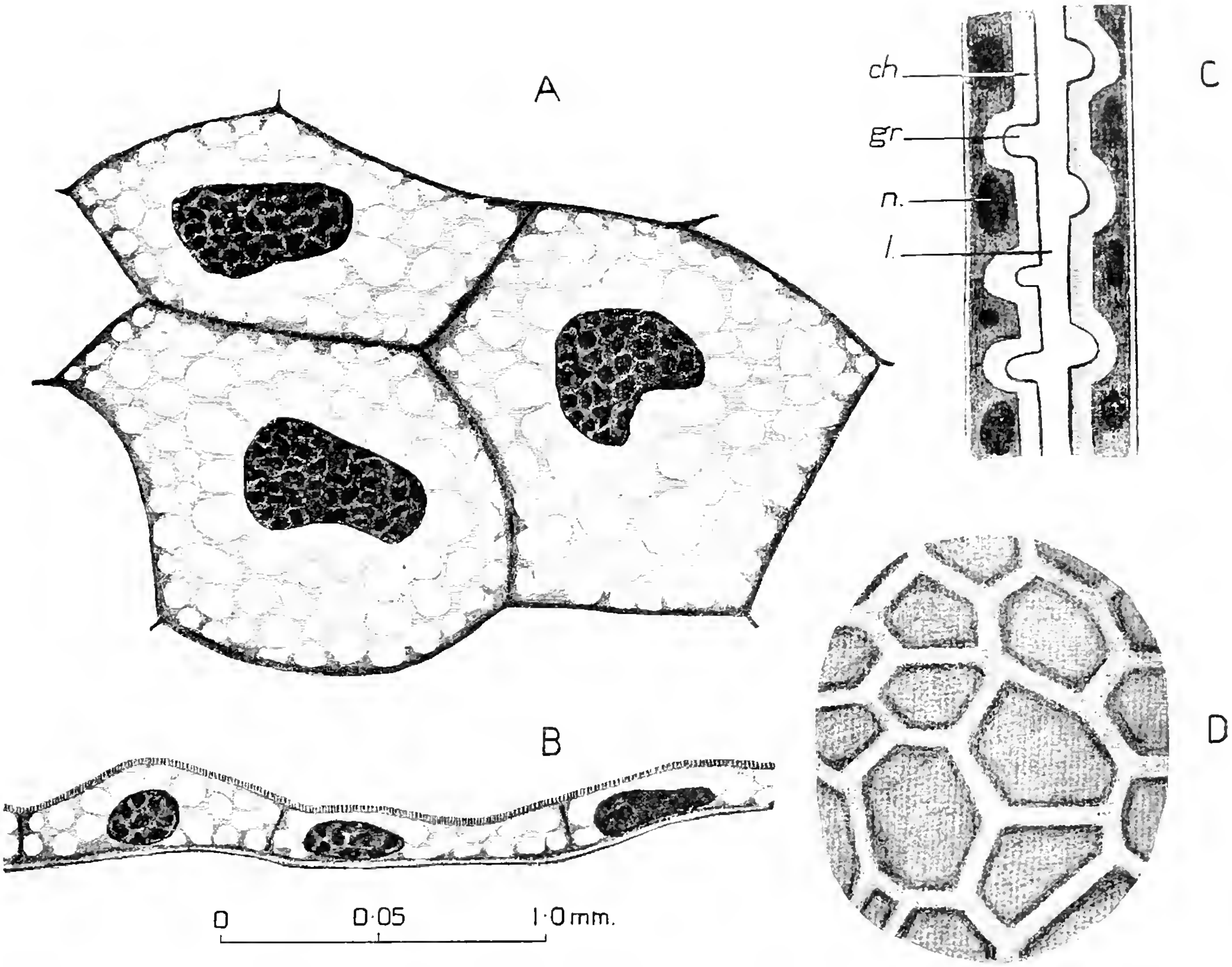


Fig. 5. A. Cells of the digestive sac in surface view. B. Same in section showing striated border. C. Section of the plated side walls of the stomach showing the grooves in the chitin as it is laid down over each cell and the closeness of the opposite walls of the gut: *ch.* chitin; *gr.* intercellular groove in the chitin; *l.* lumen of the gut; *n.* nucleus. D. Surface view of the chitin.

MUSCULATURE

The musculature of the fore-gut of *Nebaliopsis* is shown in Fig. 6 C. The similarities to the other Nebaliacea are striking. The oesophagus and stomach are sheathed in strong bands of circular muscles (*h.circ.* and *v.circ.*). These bands are many times thicker than the corresponding ones in *Nebalia*, while the tissue between them and the chitin is comparatively much reduced. They cease abruptly at the end of the fore-gut.

Acting antagonistically to these circular muscles are the dilator muscles. The dorsal dilators (*d.dil.*) are probably homologous with the anterior dorsal dilators (*a.d.dil.*) of *Nebalia*, as the groove muscles which lie close to the dorsal ridge between the anterior horns of the stomach run between them and are inserted on the dorsal wall more posteriorly. In *Nebaliopsis* the groove muscles consist of a very thick bundle of fibres passing from the dorsal ridge as mentioned above to the anterior wall of the oesophagus ventral to the anterior median projection, while only four pairs of slender strands were found in *Nebalia*. The anterior lateral dilators (*l.dil.*$_1$ and *l.dil.*$_2$) differ only in that they slope dorsally

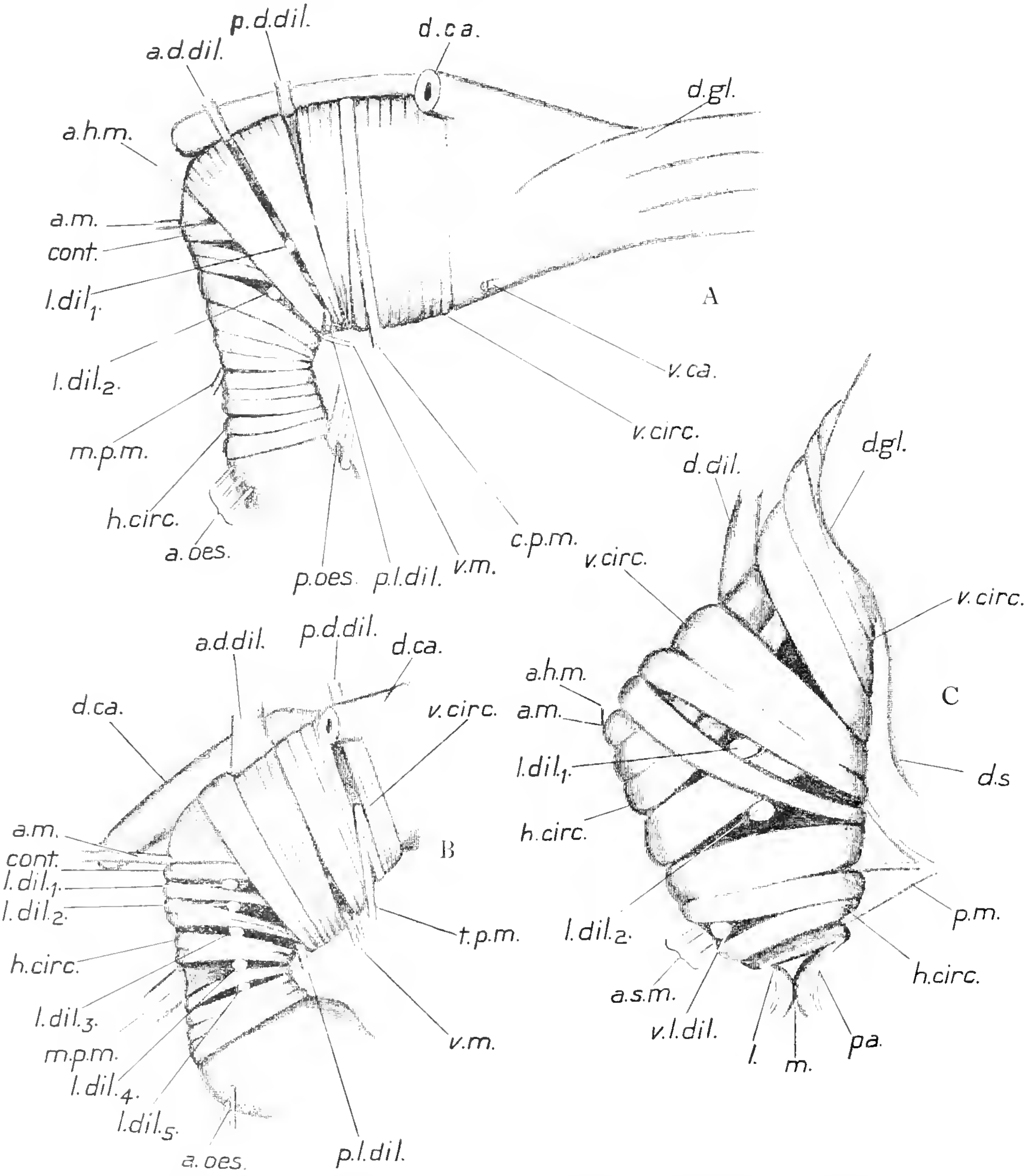


Fig. 6. Diagrams to show the musculature of the fore-gut of: A, *Nebalia*; B, *Nebaliella*; C, *Nebaliopsis*. *a.d.dil.* anterior dorsal dilators; *a.h.m.* muscles of the anterior horns of the stomach; *a.m.* median anterior muscle; *a.oes.* anterior oesophageal muscles; *a.s.m.* small anterior muscles; *cont.* strong contractor muscle; *c.p.m.* cardio-pyloric muscles; *d.ca.* dorsal caeca; *d.dil.* dorsal dilator; *d.gl.* digestive glands; *d.s.* digestive sac; *h.circ.* horizontal circular muscles; *l.* labrum; *l.dil.*$_1$, *l.dil.*$_2$, *l.dil.*$_3$, *l.dil.*$_4$, and *l.dil.*$_5$, points of insertion of the lateral dilators; *m.* mouth; *m.p.m.* median projection muscle; *pa.* paragnaths; *p.d.dil.* posterior dorsal dilators; *p.l.dil.* posterior lateral dilators; *p.m.* posterior muscles; *p.oes.* posterior oesophageal muscles; *t.p.m.* muscles of the trilobed process; *v.ca.* ventral caeca; *v.circ.* vertical circular muscles; *v.l.dil.* ventro-lateral dilators; *v.m.* small ventral muscles.

instead of ventrally. A small ventro-lateral dilator muscle (*v.l.dil.*), three small muscles (*a.s.m.*) extending anteriorly and a muscle (*p.m.*) pulling posteriorly from a triple insertion on the gut were found. The anterior muscles (*a.m.* and *a.h.m.*) are small but correspond to similar muscles in *Nebalia*.

The digestive sac has dorsally and ventrally a pair of longitudinal muscle bands. Small segmental muscles which support the thoracic limbs lie in the wall of the sac and cause slight ridges in it. No musculature was found on the intestine and only a small sphincter at the anus (*a.sp.*).

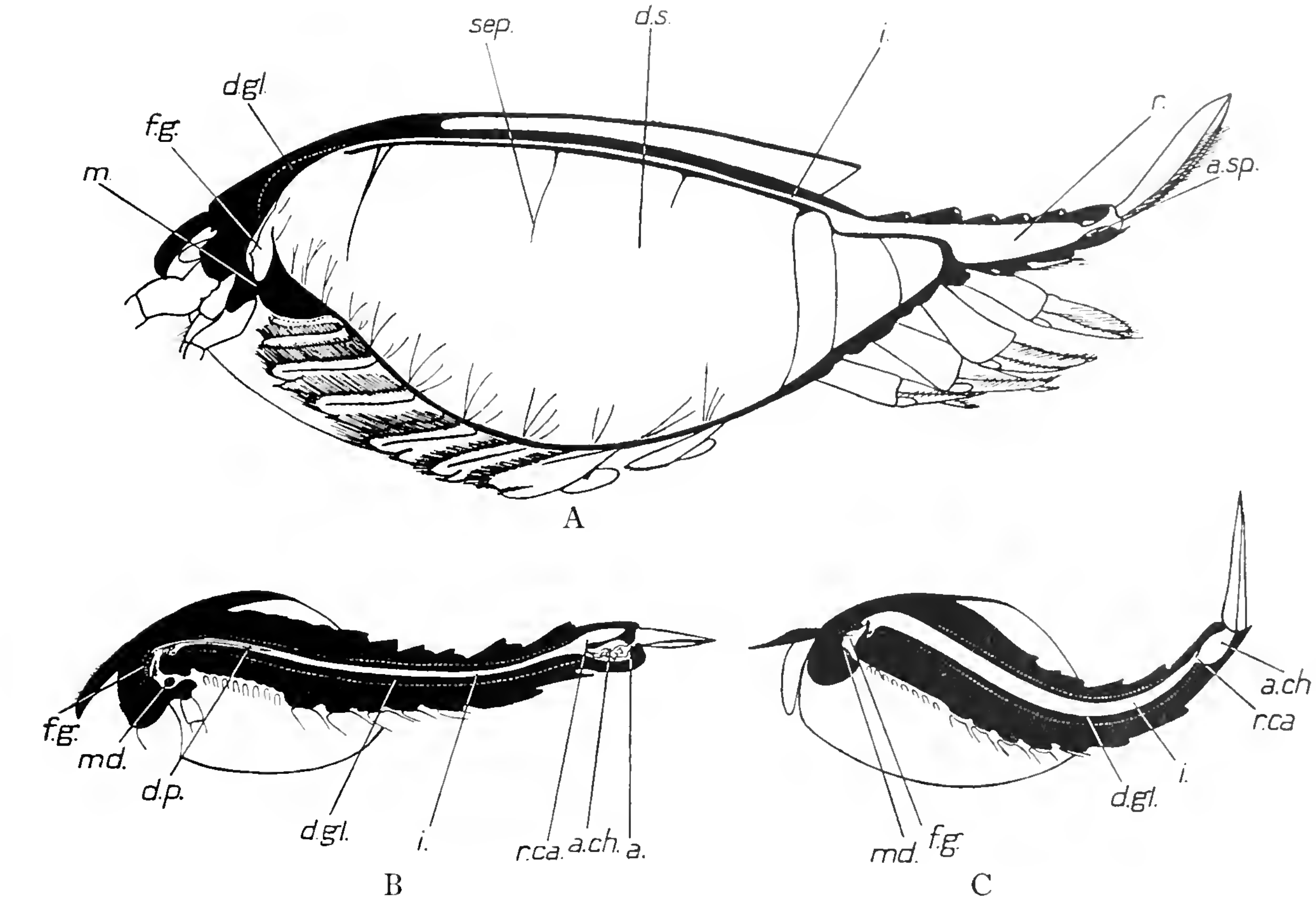


Fig. 7. Diagrams of the right halves of A, *Nebaliopsis*, B, *Nebalia*, and C, *Nebaliella*, showing the position of the gut in the body cavity of each. (The positions only of the limbs are indicated in B and C.) *a.* anus; *a.ch.* anal chamber; *a.sp.* anal sphincter; *d.gl.* digestive glands; *d.p.* dorsal process projecting down the intestine; *d.s.* digestive sac; *f.g.* fore-gut; *i.* intestine; *m.* mouth; *md.* mandible; *r.* rectum; *r.ca.* rectal caecum; *sep.* septum.

THE STRUCTURE OF THE GUT OF *PARANEBALIA LONGIPES*
(Wilemoes Suhm)

No specimens of *Paranebalia* were available for examination. Nevertheless, to complete the survey of the Nebaliacea Thiele's description may be quoted. He found that the gut is, on the whole, like that of *Nebalia*, but records these differences: (1) strong spines are present under the long setae on the ventral side of the 'hypopharynx' (the ventral lip); (2) the rows of setae on the dorsal ridge in the pyloric region do not extend far back, and the funnel formed by the dorsal process bears no setae; (3) two ventral bristle plates take the place of the small lateral ridges (*l.r.*) of *Nebalia*. These plates are composed of a transverse row of thick setae which meet each other across the lumen of the gut. The midmost setae are longest.

Thiele's diagram does not show an anterior median projection, lateral plate setae (but he has depicted the left side), setae on the walls of the oesophagus or cardiac region, or a ventral cardio-pyloric valve, but he does not mention these points as differences. Therefore either his description is inadequate or his diagram incorrect. In the absence of further material the answer to this question cannot be given.

MODE OF FUNCTIONING OF THE GUT OF *NEBALIA BIPES*

The mode of functioning of the gastric mill of *Nebalia bipes* may be deduced from evidence furnished by the structure of its parts, the distribution of particles within the gut, and also from observation of living animals.

Specimens kept in shallow water in a jar, on the bottom of which was mud from their natural habitat, were observed undisturbed. They occasionally swam about, but usually lay on the surface of the mud (often in the shadow of large pieces of seaweed or stones), where it could be seen that the thoracic limbs seldom ceased their regular rhythmic motion even when the animal as a whole was stationary. They appeared to burrow only when disturbed.

When isolated in small dishes and placed under the microscope they swam rapidly but at times lay quiescent and could then be studied. The thoracic limbs continued to beat unless the specimens were kept long in these conditions when they frequently became completely inactive for considerable periods though often reviving later. When all the movement of the limbs ceased in this manner the rate of heart beat slowed down and large particles were seen floating in the blood stream. This effect has not been studied in detail but it is probably caused by the unnatural conditions in the dishes, as no such long pauses in the motion of the thoracic limbs were noted when watching the animals in the jar.

The currents produced by the movements of the thoracic limbs bring particles to the filter apparatus (Cannon, 1927). There is thus a continuous supply of food depending only on the concentration of suspended matter in the water. If excessive amounts are collected the particles are gathered into balls and shot out ventrally in the anterior region of the carapace. This mechanism probably helps to prevent the filter apparatus from being choked with mud when the animal is burrowing and also indicates that the movement of the thoracic limbs serves another purpose besides feeding. It is possible that the continuous current of fresh water is necessary for respiration and must be maintained whether it bears many or few particles. Thus normally there is a constant stream of filtered material being passed to the mouth. Large particles have a preliminary grinding by the maxillary endites (see Cannon, 1927, for details), and are also ground between the mandibles.

Rows of setae on the lips prevent pieces from falling off into the grooves on either side of the mandibles and direct them into the oesophagus. Strong contraction of the circular muscles keeps the passage from the oesophagus to the stomach closed most of the time, but periodically these muscles are relaxed, and simultaneously the lateral dilators work actively causing a 'puff' of particles to pass into the stomach and swiftly back into the pyloric region and the intestine. Setae on the walls of the oesophagus point dorsally and prevent backflow. All the gut muscles move violently during this operation.

The anterior median projection and the lateral plate setae (*a.m.p.* and *l.p.*) help to direct the current round the angle between the oesophagus and the stomach so that large amounts of material do not pass dorsally and choke the grinding tubes. The setae are, however, not close enough to form a strict filter, and some particles pass up into the grinding tubes and are ground between the setae (*g.s.*$_1$) and the vertical ridges (*v.r.*) and spines (*g.s.*$_2$), which are rubbed across one another by a complex circular and see-saw motion of the dorsal ridge, easily seen in living specimens and probably caused by alternating contraction of the dorsal dilators combined with peristalsis of the circular muscles. Only liquid was found in the dorsal channels (*d.ch.*), which are open posteriorly, and it is possible that a secretion from the dorsal caeca may flow forwards in them and be poured upon the food as it is being ground up in a manner analogous to Yonge's suggestion for *Nephrops* (Yonge, 1924).

The particles from the grinding tubes are passed back and on to the long setae of the pyloric region. The narrowness of the lumen of the gut in the posterior part of the cardiac section and the presence of the ventral cardio-pyloric valve (*v.v.*), whose tip moves violently describing an ellipse, causes particles which have been driven directly back without secondary grinding in the grinding tubes to pass up on to these setae also. The latter filter off the larger pieces and bear them back beyond the openings of the digestive glands and far down the intestine in the tubular extension of the dorsal process. The smaller pieces fall through into the ventral pyloric chamber and pass into the digestive glands (*d.gl.*). Muscle bands on the walls of these glands probably cause pumping in and out of fluid bearing small particles as in *Nephrops* (Yonge, 1924). Certainly in ink-fed specimens grains were found far into these caeca indicating that particles from the stomach are passed into them. Particles appearing like finely ground food were frequently found in them also. No ink grains or other particles could be seen in either the dorsal or ventral caeca (*d.ca.* and *v.ca.*). This suggests that absorption as well as digestion probably takes place in the digestive glands, while the dorsal and ventral caeca secrete a digestive fluid only.

The arrangements of the gastric mill of *Nebalia* are such that there is continuous action of the secondary grinding apparatus which increases the number of particles small enough to pass into the digestive glands, while at the same time the animal is able to deal casually with the large quantities of potential food which are automatically available and whose amount depends only on the concentration of particles in suspension in the water filtered and the proportion of inorganic to organic matter.

MODE OF FUNCTIONING OF THE GUT OF *NEBALIELLA EXTREMA*

Nebaliella is a mud-living form. The eyes and rostrum have been shown by Cannon (1931) to be a mechanism whereby mud is prevented from entering the space within the carapace and choking the filter apparatus as the animal burrows. Variations in the completeness of closure of this apparatus control the current entering the filter chamber. Particles found amongst the mouthparts and also within the gut include large pieces of diatom skeletons, radiolaria, and many unidentifiable broken pieces showing that the animal is an indiscriminate mud feeder and also that it can deal with relatively coarse filtered food. That these particles are present far down the intestine indicates that there is no very efficient grinding of the food. It is probable that as in *Nebalia* much material is passed through rapidly and a little is more carefully treated.

That particles passed on to the mandibles receive only slight grinding before entering the oesophagus is shown by the state of the food within the gut. The sheath of circular muscles probably functions in the same way as in *Nebalia* and releases particles spasmodically.

The angle between the oesophagus and the stomach is more obtuse than in *Nebalia*, the anterior median projection is much reduced and the lateral plate setae are absent, but clogging of the grinding setae ($g.s._1$) is prevented by an entirely different mechanism. In the anterior region the edges of the horizontal shelves of the side walls almost touch the small ridges (*d.r.'*) on the dorsal ridge so that the channels containing the setae ($g.s._1$) are nearly closed and only relatively small particles can enter them. These particles are ground between the setae and the shelf and when fine enough pass between the former and are found as a 'felty' layer on the dorsal side of them. This arrangement and the general reduction in the numbers of setae are almost certainly correlated with the coarse texture of the food against the passage of which fine setae would have no effect. Such setae would soon be broken or worn away. The spines ($g.s._2$) may have some guiding effect on the current, but as they are so short they are probably only a relic of their homologues in *Nebalia*.

There is no filter mechanism in the pyloric region. The openings of the digestive glands are small, and only most minute particles were found within them. In the absence of more material the mechanism which prevents the openings of the digestive glands from being occluded by large particles is uncertain, but the following is a possible interpretation of the structures found. The long projections on the lateral and ventral pads form a triple barrier across the lumen. This barrier is augmented by the long setae on the lateral pads. As a large mass of food is passed back it comes up against the barrier and depresses the projections so that a bridge is formed which guides the particles across the pyloric chamber into the intestine. This movement causes the lobes from which these projections rise to be bent backwards and downwards to fill a large part of the ventral chamber, occlude the openings of the digestive glands and at the same time press digestive secretion from the chamber out on to the food as it enters the intestine. Elasticity for this movement is provided by the large blood sinuses within the lateral pads and below the ventral one just anterior to the point where they become free. When the food has passed, the projections spring back to the vertical position assisted by the powerful muscles in the lateral lobes of the process. The pyloric chamber is thus opened once more and ready to be refilled with secretion from the digestive glands.

The structure of the digestive glands is such that they are probably almost entirely secretory, while a little digestion and absorption of the small amount of finely divided material which enters them may also take place.

The dorsal caeca are entirely secretory as in *Nebalia.*

The structure of the intestinal wall suggests that besides absorption there is additional secretion of digestive enzymes especially in the anterior region.

MODE OF FUNCTIONING OF THE GUT OF *NEBALIOPSIS TYPICA*

The mode of functioning of the various parts of the gut of *Nebaliopsis* cannot be described with certainty as yet, for in specimen E hardly any particles were present and in specimen F2 the digestive sac was full of an almost homogeneous mass resembling coagulated yolk, but two alternative mechanisms are here suggested, the second being the more probable.

I. Fine particles filtered out of the water by the maxilla and first trunk limb (Cannon, 1931) may be sucked into the stomach by the action of the lateral dilators and the circular muscles. There can be no preliminary grinding owing to the structure of the mouthparts, but once within the gut any large pieces may be ground between the dorsal ridge (*d.r.* Fig. 4) and the lateral thickenings (*l.th.*) and also between the side walls which approach each other very closely and are heavily chitinized and grooved (Fig. 5 C, D). There are no setae to hinder direct passage of food into the digestive sac, therefore it cannot remain long in the fore-gut. Digestive secretion is poured on to it as it passes the openings of the anterior digestive diverticula (*d.gl.* Fig. 7 A). These openings are large and unprotected and particles could easily enter them, but the structure of the glands does not suggest that any absorption takes place within them.

There is no possibility of any food passing straight from the fore-gut to the intestine as it does in *Nebalia* and *Nebaliella.* Everything must enter the sac where both digestion and absorption probably take place.

It is difficult to visualize how the sac does not become clogged with indigestible matter, as there is no apparent means of circulating the material in it. A possible explanation is that a deep pelagic filter feeder will obtain very little particulate inorganic matter such as is so abundant in and near the surface of mud so that digestion will be almost complete. Filterable particles are scarce in this zone, and the blind diverticulum permits the retention of all material until it is thoroughly digested thus preventing waste.

This suggested mechanism agrees with Cannon's belief that *Nebaliopsis* is 'entirely a filter feeder'. His conclusions were reached from a study of the mouthparts alone, particularly important being the facts that 'the whole mouth armature is extremely soft and unsuited for dealing with large food particles', and that 'in addition there is a complicated structure which, in my opinion, must be a filter'. The internal organization, however, and other considerations, make probable the following alternative mechanism, in which the first of these facts plays an important part.

II. *Nebaliopsis* is probably an egg sucker. As far as information is at present available eggs of various types have been found in small numbers in all the hauls in which *Nebaliopsis* has been collected. The mechanism by which it sucks the yolk from these eggs is probably as follows.

As Cannon reports, the mandibular palps are long and armed at the tips with stout claw-like setae, which grip the slippery surface of the egg. The eddy currents round the mouth caused by the movements of the trunk limbs and mouthparts also help to keep the egg pressed against the mouth. The molar processes of the mandibles are soft and useless for biting; thus the egg is not punctured outside the mouth, where there would be great risk of the contents being washed away by the water currents in that region.

While being held close to the mouth one side of the soft egg is sucked into the oesophagus by the pumping action of the muscles on its walls. It is then gripped tightly by the plated surfaces of the lateral walls, while the biting action of the dorsal ridge against the dorso-lateral thickenings of the chitin makes a hole in the egg membranes. The liquid yolk is then pumped through this puncture into the digestive sac, digestive secretion being poured on to it as it passes the openings of the anterior glandular caeca. The great thickness of the muscle sheath of the fore-gut may be associated with this strong pumping action. The steadying action of the mandibular palps and the eddy current round the mouth are most important during this process. The empty egg case would then be thrown away.

The capacity of the digestive sac is sufficient to accommodate the contents of several average-sized fish eggs. As suitable eggs are likely to be found in groups near where they have been spawned, and only at certain times of year, a meal is available only at infrequent intervals. Much food is thus taken at one time and is stored in the immense digestive sac where it is assimilated slowly as required.

There is hardly any solid waste in this method of feeding, which agrees well with the observed structure of the extremely narrow intestine and the lack of through current or strong muscles by which solid waste could be evacuated from the blind digestive sac. It also agrees with the fact that no 'structure' was found in the solidified mass in the sac, as would be expected if particulate matter were collected indiscriminately by a filter mechanism or indeed if *Nebaliopsis* fed on anything but liquid or semi-liquid food. There is nothing in the structure of the mouthparts or gut to suggest that it is a blood sucker, and the appearance of the food undoubtedly suggests coagulated yolk.

In the depths from which *Nebaliopsis* has been collected there can be very little finely divided material for a filter feeder—only the slow rain of dead plankton from the surface layers. An animal of the size of *Nebaliopsis* will require a considerable amount of food. The second theory would supply this better than the first. As has been shown, the structure of the gut and especially the presence of the large digestive sac also indicate that an occasional large meal is taken. It is possible that the animal depends chiefly on sucking eggs, but has a filter mechanism which provides a small additional supply of food, alone insufficient, but valuable when prey is scarce.

Without intermediate forms it is impossible to tell how this complex and highly specialized mechanism originated. It is undoubtedly, however, well adapted to the environment in which the species now lives.

CONCLUSIONS

The structure of the gut differs considerably in the different members of the Nebaliacea, and many of the changes may be correlated with the feeding habits.

The greatest similarities are found in the musculature. It is obvious that for the efficient working of a complicated chitinized apparatus simple peristalsis of circular muscles is insufficient. Opposing dilators are necessary. The oesophagus of Crustacea almost invariably has lateral dilator muscles and others are associated with the teeth and other grinding parts. In the Nebaliacea the dorsal ridge always forms part of the grinding organ of the gastric mill and at least one dorsal dilator is present in all species.

Other muscles are developed in association with special parts or functions; for example, the muscles (*t.p.m.* Fig. 6 B) which move the trilobed process of *Nebaliella* back to the vertical position after the food has passed, and those (*v.m.* and *c.p.m.* Fig. 6 A) which cause the elliptical motion of the tip of the cardio-pyloric valve in *Nebalia*.

The numerous small muscles which are not attached to particular structures in the gut probably function in steadying the whole organ in relation to the other parts of the body.

Thus, though the plan of the musculature is simple and constant, the changes may be associated with the structure of the chitinous parts, and these in turn may be correlated with the habits of the species concerned.

Nebalia and *Nebaliella* both live where the bottom deposits are muddy, but observations of the former, when living, show that it lies most of the time above the mud just beneath or amongst larger debris of pieces of seaweed, shells and stones. The particles on which it feeds are thus the small ones in suspension in this zone. *Nebaliella*, on the other hand, appears to be a true mud dweller. The specializations of the eyes, rostrum, and antennae are adaptations to burrowing, and the food particles found amongst the limbs and in the gut indicate that it feeds indiscriminately on the mud. Many of the particles are too large to stay long in suspension. Therefore it must either allow some to pass into the carapace chamber as it burrows or kicks up the mud and then filter rapidly before it settles (as on occasions does *Chirocephalus*).

In this mud there is a much higher percentage by volume of silica and other inorganic matter than in the suspension of finer particles taken by *Nebalia*. This means that the material which *Nebaliella* swallows has a lower food value, and there must be more of it. The mechanism, which is already present in *Nebalia*, for rapid dealing with much food is elaborated and that for efficient grinding of a little is reduced. The food is largely retained in the through passage of the gut and not passed into the diverticula. In this way the indigestible particles are passed on rapidly, and such nutriment as can be easily extracted by the digestive enzymes is obtained. In morphological association with this, the openings and lumina of the digestive glands, are reduced and the lumen of the intestine increased, and in place of the filter allowing the passage of selected finer particles into the glands there is a mechanism whereby they are almost all excluded and passed straight on down the intestine.

Thus the differences between the structure of the gut of *Nebalia* and that of *Nebaliella* may be definitely associated with the habits of these animals and the food thus made available.

Nebaliopsis, which has so far been found only at great depths in the open ocean, is in very different surroundings from the bottom-living forms. It is only to be expected that adaptations to these conditions would cause specializations, such as are found both in the external and in the internal structures. The form of the gut may be correlated with the difference in food.[1]

Filterable particles are much scarcer in this zone, and, as has already been shown, the mechanism whereby much useless material is passed rapidly through the gut has disappeared. A special method for dealing with an entirely different type of food has been developed. This food is almost certainly eggs, and in adaptation to the periodic abundance and scarcity of these the large digestive sac has been developed as a store chamber and the lumen of the intestine has been reduced to insure that

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[1] Since the above was written my attention has been drawn to a description by T. J. Evans (Q.J.M.S. 1922, LXVI N.S. p. 439) of *Calma glaucoides*, an Aeolidiomorph Nudibranch which feeds exclusively on 'the eggs and embryos of the smaller shore fishes'. The amazing similarity between the adaptations of this mollusc to an egg diet and the specialized structure of *Nebaliopsis* forms additional evidence that the latter also feeds on eggs. This is a remarkable case of parallel adaptive evolution in two animals widely separated in phylogeny, habits and habitats and it is hoped to elaborate the comparison elsewhere.

nothing escapes thorough digestion. The fore-gut is adapted to the puncturing and sucking of the eggs and the mandibles to holding them in position during these processes.

Interesting parallels to the development of a large storage chamber when an occasional meal is taken are to be seen in the Decapoda and in the Anaspidacea. In the former group there is a swelling of the anterior region of the cardiac portion of the stomach in all the predatory forms examined, while in *Porcellana*, which has been shown by Nicol (1932) to be a filter feeder, there is no such swelling. Similarly in the Anaspidacea, *Koonunga cursoria*, which has been shown by Cannon and Manton (1929) to have 'given up filter feeding completely', has a long tubular storage section of the fore-gut which is absent in *Anaspides* and *Paranaspides*, which are filter-feeding forms.

In the above three examples the same result has been attained by entirely different means.

The gut is in more direct contact with the environment than any other internal organ and is thus more subject to the same influences as act upon the external features. The type of food available not only influences the method of capture and the mouth parts, but also the structures which have to deal with it later on. An attempt has here been made to show how the digestive mechanism of the Nebaliacea may be correlated with the habits and habitats of these animals as far as can be deduced from present knowledge of this rare group in which so many evolutionary links are missing.

The greater part of this work was carried out in the Zoology Department of the University of Manchester while holding the Grisedale Research Scholarship. I wish to thank Professor Graham Cannon and Dr S. M. Manton for the loan of fixed material, Mr G. A. Steven for the living specimens of *Nebalia*, specially collected along with characteristic elements of their habitat, and all three for much helpful advice and criticism.

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ON A SPECIMEN OF THE SOUTHERN BOTTLE-NOSED WHALE, *HYPEROODON PLANIFRONS*

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(Text-figs. 1–11)

INTRODUCTION

The specimens of *Hyperoodon planifrons*, the Southern Bottlenosed Whale, of which there are published accounts, are few enough in number to be detailed. The type of the species in the British Museum collection is an imperfect, partly waterworn skull (Reg. no. 1814 A) from Lewis Island, Dampier Archipelago, North-Western Australia, described and figured by Flower in the *Proceedings of the Zoological Society* (1882). In the *Anales del Museo de la Plata* (1895), F. P. Moreno gives a brief account of three specimens:

(1) Skeleton of an adult from the coast of the province of Buenos Aires.
(2) Skull of an adult, Chubut Territory, Patagonia.
(3) Skeleton of a young animal, Santa Cruz Bay, Patagonia.

Finally, the *Records of the South Australian Museum*, vol. IV, no. 3, 1931, contains an account by H. M. Hale of a male which stranded near Port Victoria, Yorke Peninsula, South Australia.

The present paper is concerned with the description of a skeleton from South Georgia, presented to the British Museum (N.H.) by the Discovery Committee, with an appended note about two additional specimens, no part of which has been preserved, from South Georgia and the South Orkneys respectively, in the Falkland Islands Dependencies.

The widely separated regions from which the Southern Bottlenose has been recorded indicate the great area of distribution of this species. It may be presumed that its range includes the Southern Ocean generally and extends into the warmer parts of adjacent seas in the southern hemisphere.

The Discovery skeleton (Reg. no. 1934.7.23.3) belonged to an animal 6·5 m. long, a female, which was presented to the Discovery Committee by Capt. Sorlle, Westfold Whaling Co., Stromness, South Georgia.

The skull and axial skeleton are in very good condition and almost complete, only the slender zygomatic arches in the skull, one or two of the terminal bones in the caudal series of vertebrae and probably one chevron being lacking. The appendicular portions of the skeleton are missing except the scapulae which are damaged.

The sutures of the skulls of the Discovery specimen are all well defined and the epiphyses throughout the length of the vertebral column are not fused to the centra. In the South Australian specimen, which was only 0·4 m. larger, Hale states that the sutures of the skull are more or less ankylosed, and the figured vertebrae show no trace of separate epiphyses. These features suggest that, unlike the northern *H. rostratus*, in which the physically mature female is appreciably smaller than the male, in *H. planifrons* the two sexes must be about the same size when fully grown.

Recorded dimensions of skulls of *H. planifrons*, together with the dimensions of a skull of *H. rostratus* for comparison, are given in Table 1.

LATERAL VIEW OF SKULL (Fig. 1)

In the description of the type specimen Flower (1882) drew attention to two features distinguishing *H. planifrons* from *H. rostratus*, both of which are most obvious in the lateral view of the skull. The first, the character which gives *H. planifrons* its specific name, is the relatively low development of

Table 1. *Skull measurements of* Hyperoodon planifrons *with those of a specimen of* H. rostratus *for comparison*

	La Plata Mus. no. 6		La Plata Mus. no. 3		La Plata Mus. no. 4		Discovery specimen ♀		Type specimen		South Australian ♂		*Hyperoodon rostratus*	
	mm.	%	mm.	%	mm.	%	mm.	%	mm.	%	mm.	%	mm.	%
Total length	813	100	1150	100	—	—	1193	100	—	—	1391	100	1333	100
Height of supra-occipital from upper margin of foramen magnum to top of occipital crest	235	28·9	322	28·0	330	—	348	29·1	375	—	410	29·5	295	22·1
Width of supra-occipital at narrowest part between hinder margins of temporal fossae	279	34·3	335	29·1	360	—	374	31·3	375	—	*485	34·9	413	31·0
Width of foramen magnum	63	7·7	75	6·6	60	—	60	5·0	68	—	60	4·3	78	5·9
Height of skull to vertex	393	48·3	500	43·5	510	—	525	44·0	—	—	666	47·9	505	37·9
Greatest width of skull	445	54·7	610	53·0	605	—	601	50·4	—	—	—	—	665	49·9
Least width between orbital processes	422	51·9	603	52·4	573	—	593	49·7	—	—	—	—	631	47·3
Width of rostrum between antorbital notches	273	33·6	387	33·6	378	—	386	32·3	432	—	500	35·9	379	28·4
Width of rostrum between mastoid processes	368	45·3	477	41·4	480	—	496	41·6	513	—	—	—	511	38·3
Length of rostrum (to antorbital notches)	450	55·4	695	60·4	—	—	688	57·7	—	—	857	61·6	823	61·8
Width of base of maxillary crest opposite antorbital notch	105	12·9	147	12·8	138	—	141	11·8	160	—	200–204	14·4–14·7	119	8·9
Greatest height of crest of maxilla	76	9·3	107	9·3	130	—	101	8·3	98	—	—	—	234	17·5
Height from bottom of nasal cavity to occipital crest	195	24·0	275	23·9	263	—	283	23·7	260	—	—	—	205	15·4
Greatest length of pterygoids	300	36·9	390	33·9	380	—	370	31·0	—	—	—	—	393	29·5
Tip of rostrum to posterior free border of pterygoids	—	—	—	—	—	—	948	79·4	—	—	1141–1150	82·0–82·7	1065	79·9
Tip of rostrum to anterior end of nasals	—	—	—	—	—	—	863	73·2	—	—	1065	76·6	1090	82·1
Breadth of rostrum in front of maxillary crests	—	—	—	—	—	—	170	14·6	*c.* 190	—	210	15·1	*c.* 161	*c.* 12·1
Width of occipital condyles	125	15·4	190	16·5	—	—	209	17·5	212	—	237	17·0	263	19·7
Height	—	—	—	—	—	—	149	12·5	138	—	174	12·5	—	—
Length of mandible	692	85·1	975	84·9	—	—	978	82·0	—	—	1184	85·1	1094	82·1
Length of symphysis	182	22·4	288	25·0	—	—	312	26·2	—	—	392	28·2	331	24·8
Depth of mandible at coronoid	121	14·9	166	14·4	—	—	171	14·3	—	—	218	15·7	182	13·6

* Hale gives 85 mm. for this measurement, obviously a misprint for 485 mm.

the maxillary crests. These in *H. rostratus* originate anteriorly approximately equidistantly between rostrum tip and antorbital notch, and ascend in a slope which varies according to age to a summit which overtops the skull vertex in all but the most juvenile specimens. Posterior to the summit there is a decline in level which is generally more abrupt than the anterior slope, the maxillary bone attaining normal thickness again before it ascends posteriorly in contact with the vertical portion of the frontal. The crests in *H. planifrons* originate anteriorly about two-thirds from the anterior end of the distance between rostral tip and antorbital notch. The slope is gradual to a low summit above the antorbital notch, and the decline posteriorly is equally gradual so that there is no horizontal thin portion of maxillary before it rises vertically in contact with the frontal in the occipital crest. In the Discovery specimen the maxillary crests are less massive than in the South Australian specimen. It may be that the difference is associated with sex, but it may equally well be due to difference in age.

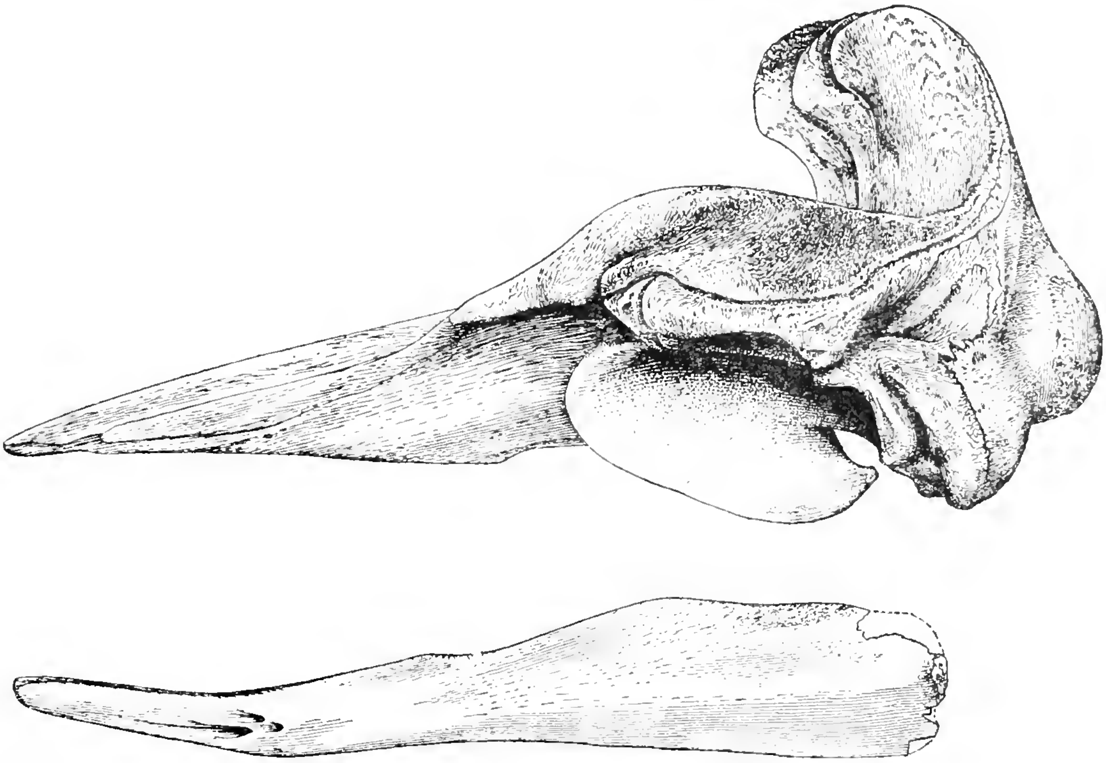


Fig. 1. Lateral view of skull and lower jaw. ($\times \frac{1}{8}$.)

The second feature referred to by Flower, and visible in the lateral view of the skull, is the much larger size in *H. planifrons* of the crest formed by the vertex behind the nares. Not only is it much larger than in *H. rostratus* but it differs somewhat in shape, overhanging the narial area considerably, whereas in *H. rostratus* the anterior face of the crest viewed in profile is approximately vertical. Other differences will be mentioned when describing the dorsal aspect.

In skulls of comparable size the distal portion of the rostrum is more slender in *H. rostratus* than in *H. planifrons*. The differences which exist in the proximal portion are associated with the dissimilarity of the maxillary crests. The distance of the maxillary tip from the tip of the premaxilla is alike in both species.

The extent to which the lachrymal is seen in the lateral view appears to be equally variable in both species. The type specimen of *H. planifrons* has the left lachrymal completely separating the malar anteriorly from the orbital process of the frontal posteriorly and it has a wide contact with the maxilla. In the Discovery specimen it hardly appears in lateral view. It does not nearly reach the maxilla, and the malar and frontal are in contact above it. The *H. rostratus* specimens examined showed a variety of form in the lachrymal. In one it did not appear in lateral view, in another there was a ventral portion separated from a more dorsal portion by a considerable extent where malar and frontal were in contact, and in a third the lachrymal completely separated malar from frontal and was in contact dorsally with the maxilla. This variation in the *H. rostratus* lachrymal is apparently connected neither with the age nor the sex of the animal.

The temporal fossa in the Discovery specimen, like that of the type, is higher and shorter antero-posteriorly than that of *H. rostratus*. Apart from these differences the general form of the skulls is very similar and confirms the generic affinity of the two species with each other.

DORSAL VIEW OF SKULL (Fig. 2)

The differences between *H. rostratus* and *H. planifrons* are again clearly seen in the dorsal view. The massive prominences over the nares in *H. planifrons* extend forward so that the anterior boundary of the right one is almost vertically above the premaxillary foramen. The left, smaller in size, does not extend forward quite so far, but both in this aspect shut out any view of the narial apertures. The two bones are separated from each other by a parallel-sided gap bounded by the nasals. Hale states that in the South Australian specimen 'The inner anterior edge of each nasal (at the bottom of the groove) drawn up into a low thin flange'. This is the condition in the type, but in the Discovery specimen the flanges are wanting, so that there is no median ridge at the hinder end of the groove. All the specimens show the internasal gap diverging to the left from behind forwards and contributing to the asymmetry which characterizes the whole of this region of the skull. In *H. rostratus* the narial prominences do not extend forward so as to shut out completely the view of the nares; the right boss, still larger than the left, has a greater width to length proportion than in *H. planifrons*. The internarial groove is wider, and has divergent, not parallel, sides. The nasal septum is similar in both species. It is strongly deflected to the left anterior to a pronounced emargination, and overlays to some extent the left premaxillary. Its extension forward in the gutter of the vomer is similar in the Discovery and the type specimen, in both of which it ends in the region of the posterior edge of the maxillary foramina about 100 mm. behind the level of the antorbital notches. The South Australian specimen has this ossification extending forward nearly to the antorbital notch level.

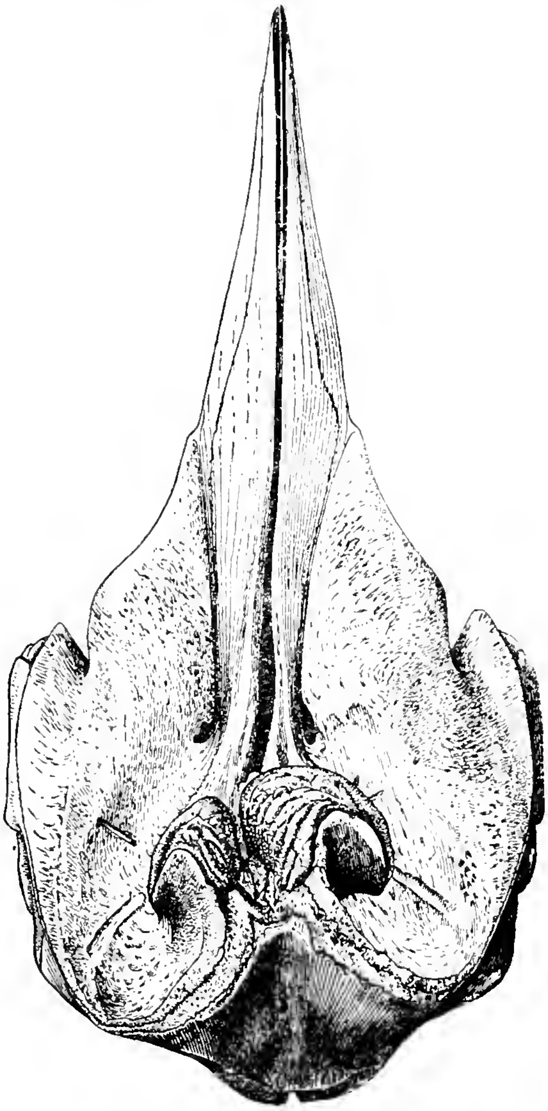


Fig. 2. Dorsal view of skull. (× $\frac{1}{8}$.)

In the region of the antorbital tubercle the outline of the skull is consistently different in the two species. In *H. planifrons* from the apex of the tubercle the external outline of the antorbital region extends posteriorly at an obtuse angle with the external edge of orbital process of the frontal, whereas in *H. rostratus* it is very nearly a right angle.

Flower drew attention to the large size of the premaxillary foramina in *H. rostratus* as compared with *H. planifrons*, and this is consistent in all the specimens so far described and figured.

The maxillary crests of *H. rostratus* rise vertically from the external margins of the maxillary foramina, and the inner faces are nearly parallel to one another. In old males especially, the crests approximate to such an extent as nearly to touch and thus form an arch over the prenarial portion of the premaxillae. The medial margins of the maxillary crests of *H. planifrons* overhang gutter-like extensions forward of the maxillary foramina. The inner faces diverge from each other at a very wide angle, and this feature, together with the lesser height of the crests in *H. planifrons*, provides one of the most conspicuous diagnostic differences between the two species.

The vomer, which is without mesorostral ossification, is visible between the overarching anterior portions of the premaxillae. Its anterior tip is nearer the end of the snout in the Discovery specimen than in the South Australian specimen, the distance being 257 mm. as compared with 380 mm. In *H. planifrons* the greatest width of the premaxillae anterior to the foramina is about midway between the foramina and the premaxilla tip. In *H. rostratus* the greatest width is at about two-thirds of the distance from the tip.

VENTRAL VIEW OF SKULL (Fig. 3)

In ventral view such differences as exist between the skull of *H. rostratus* and *H. planifrons* are of detail rather than of fundamental structure.

The vomer in both species appears as two lenticular areas in the middle line of the rostrum. The anterior area separates the premaxillaries posteriorly and the maxillae anteriorly. There is then a short length where the maxillae are in contact in the middle line before the vomer appears again, when it is bounded partly by maxillae and partly by the palatine and pterygoid bones.

The anterior portion of the vomer appears to be consistently shorter in *H. rostratus* than in *H. planifrons*.

The palatine bones in both species are in two portions, palatal and lateral, separated by the pterygoid coming into contact with the maxilla. The palatal portion is bounded by maxilla, vomer and pterygoid, the lateral part by pterygoid and maxilla. In *H. planifrons* the palatal portion is a narrow strip with a greatest width, in the Discovery specimen, of less than a centimetre, and a length of about 10 cm. Each palatal portion in *H. rostratus* is roughly triangular in outline and of greater expanse (width about 4 cm. and length 11·5 cm., in a specimen of size comparable to *H. planifrons*). This difference appears to be constant. The space between the palatal and lateral portion of the palatine, where the pterygoid anteriorly comes in contact with the maxilla, is much greater in *H. planifrons* than, in proportion to skull length, in any of the *H. rostratus* skulls in the British Museum collection. Incidentally it may be remarked that in *Berardius arnuxii* the palatal and lateral portions come into contact, being

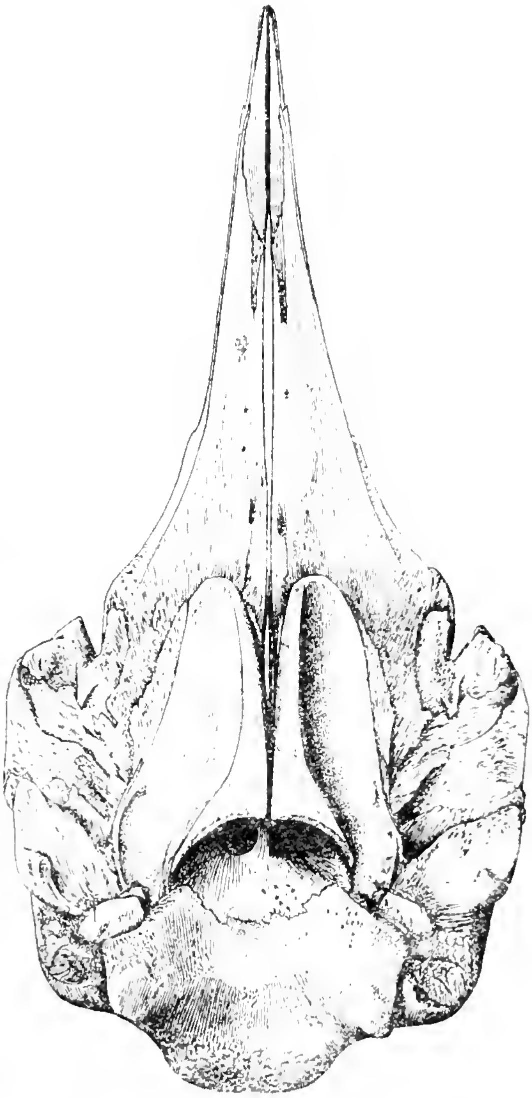


Fig. 3. Ventral view of skull. ($\times \frac{1}{8}$.)

separated from each other only by a suture. The lateral portion of the palatine is smaller in *H. planifrons* than in *H. rostratus*, and in general the impression obtained is that in the former species the pterygoid anteriorly has expanded at the expense of the bones adjacent to it.

The pterygoids are of typical ziphoid form in both species, 'large, solid, backwardly produced, meeting in the middle line, not involuted but simply hollowed on the outer surface' (Flower, 1871).

The zygomatic process of the malar has its origin much nearer the posterior border of the bone in *H. planifrons* than in *H. rostratus*, in which species it originates only a little way behind the antorbital notch. Differences in the anterior margin of the antorbital region involve the malar bone and were referred to in the description of the dorsal view of the skull.

The lachrymal, a distinct bone, has the same essential form in both species. The extent to which it appears on the lateral border of the skull has already been referred to. It is long and narrow, extending obliquely backwards from the external margin of the skull to the infra-orbital foramen. It is bounded anteriorly by the malar and maxilla and posteriorly by the orbital process of the frontal.

The external margin of the orbital process of the South Australian specimen is more pronouncedly concave than that of the Discovery specimen.

No marked differences are discernible in the squamosals either between the South Australian and the Discovery specimens or between either of these and *H. rostratus*.

The tympanic-periotic bones are very similar in *H. rostratus* and *H. planifrons*, and as in the former species so in the latter they are secured to the skull anteriorly by a slender inward-curving process from the squamosal embracing the periotic, and posteriorly by a rugose wedge-shaped extension from the tympanic between the squamosal and basi-occipital.

In the posterior view of the skull all the available specimens of *H. planifrons* show the characters to which Flower drew attention in his description of the type, namely, the narrowness and greater height compared with *H. rostratus* and also the inferior size of the occipital condyles in the southern species.

MANDIBLE (Fig. 1)

The jaws of *H. planifrons* compare closely with those of *H. rostratus* in general shape and in the extent of the symphysial region. The two rami of the mandible are not ankylosed at the symphysis in the Discovery specimen, whereas in the South Australian specimen Hale describes fusion as proceeding, the two rami being linked by ossified bridges. In the former specimen the tooth alveolus at the tip of each ramus is continuous posteriorly with the dental groove, gradually merging into it. In the South Australian specimen (Hale's Fig. 4) the alveolus appears to be sharply defined from the dental groove.

These differences between the jaws of the two specimens are such as might be expected from their difference in age.

TEETH (Fig. 4)

The outlines of the teeth of the Discovery specimen and of the South Australian specimen show the main differences between the two. Those of the former are conical and slender, and have a widely open pulp cavity. The dimensions are as follows:

	Right	Left
(1) Length	50 mm.	50 mm.
(2) Greatest diameter	18 mm.	18 mm.
(3) Diameter at right angles to (2)	17 mm.	16 mm.

The greatest diameter is just a little distance above the lower edge of the tooth, which has this indication of incipient closing of the pulp cavity. The tip of each tooth, an unworn crown of about 8 mm. length, projects from a thin investing coat of cement.

The South Australian specimen has much more massive, fusiform teeth. Their length is comparable to that of the Discovery specimen—57 and 59 mm.—but the greatest diameter is double. Apart from the difference in the pulp cavity (the root is entirely closed in the South Australian specimen) which is due to age, it is considered that the dissimilarity is associated with sex, and that in this as in other ziphoid whales the teeth of the male are large, massive and projecting above the gum, whilst those of the female are more slender, and, since the crowns are unworn, presumably concealed by the gum.

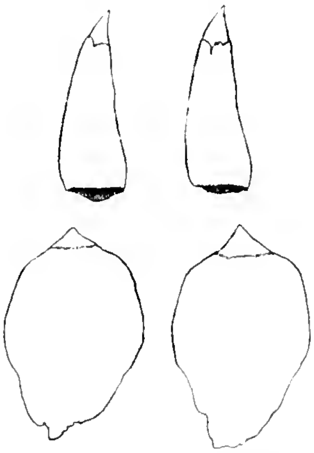


Fig. 4. Teeth of *H. planifrons*. Upper pair, ♀, Discovery specimen; lower pair, ♂, South Australian specimen. (× ½.)

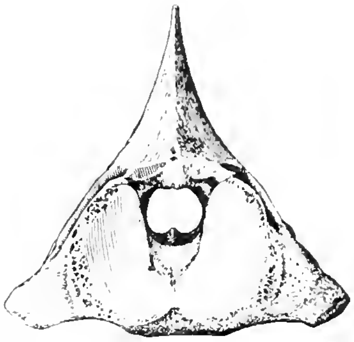


Fig. 5. Anterior view of atlas. (× ⅛.)

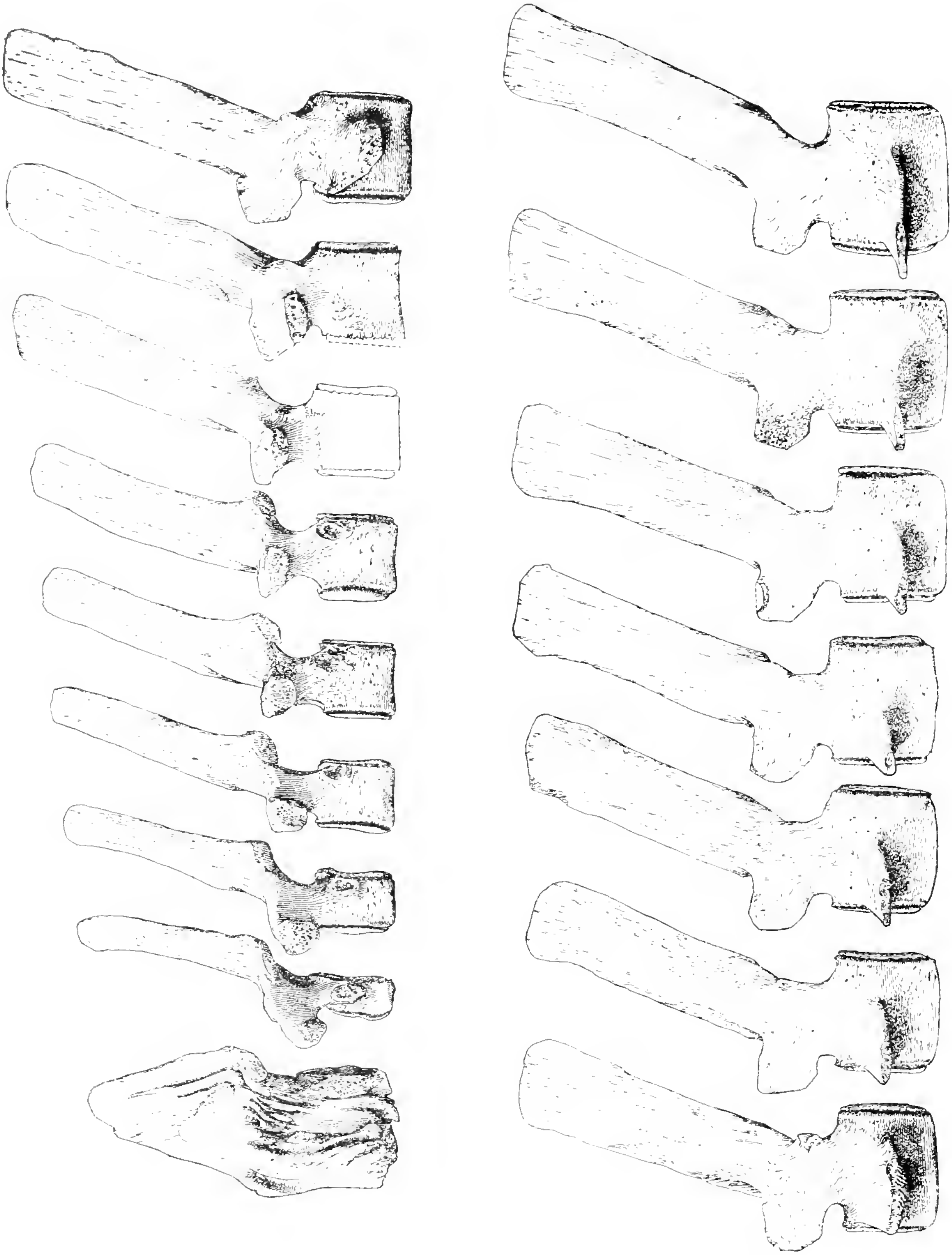
VESTIGIAL TEETH IN THE UPPER JAW

When the Discovery specimen was received the skin and dried flesh on the ventral surface of the rostrum were still attached, and on each side of the upper jaw was a row of teeth commencing at about 24 cm. from the jaw tip and extending along the jaw about 16 cm. The teeth were spaced roughly equidistantly about 8 mm. from each other. All of the teeth were not *in situ*; some had either been absorbed or had dropped out, but evidence of their existence was indicated by the fibrous follicles in which they had rested. It was estimated that each row consisted of twenty teeth, but the difficulty of dissection made exact computation impossible. Sixteen teeth were recovered on each side; most of them projected 2–3 mm. from the dried gum, but whether this post-mortem conspicuousness existed in the living animal is doubtful. Their shape is fusiform and they are slightly to moderately curved. A basal portion consisting of cement envelopes the dentine of the crown to a greater or lesser extent, in some the junction between cement and dentine being clearly defined. The root portion of some of the teeth is drawn out into a needle-like extension. This is considered to be due to absorption in process, and in the shorter teeth, in which the extension has disappeared, it is presumed that the process has gone still further. The length of the teeth ranges from 4 to 14 mm. with diameter up to 2 mm.

VERTEBRAE (Figs. 5, 6)

Vertebral formula. Cervical 7, dorsal 8, lumbar 11, caudal 17+.

Cervical vertebrae. The Discovery specimen, like the South Australian and *H. rostratus*, has all seven centra fused together. The posterior epiphysis of the seventh is still distinct. In correspondence with the superior size of the occipital condyles in *H. rostratus* the anterior articular surface of the



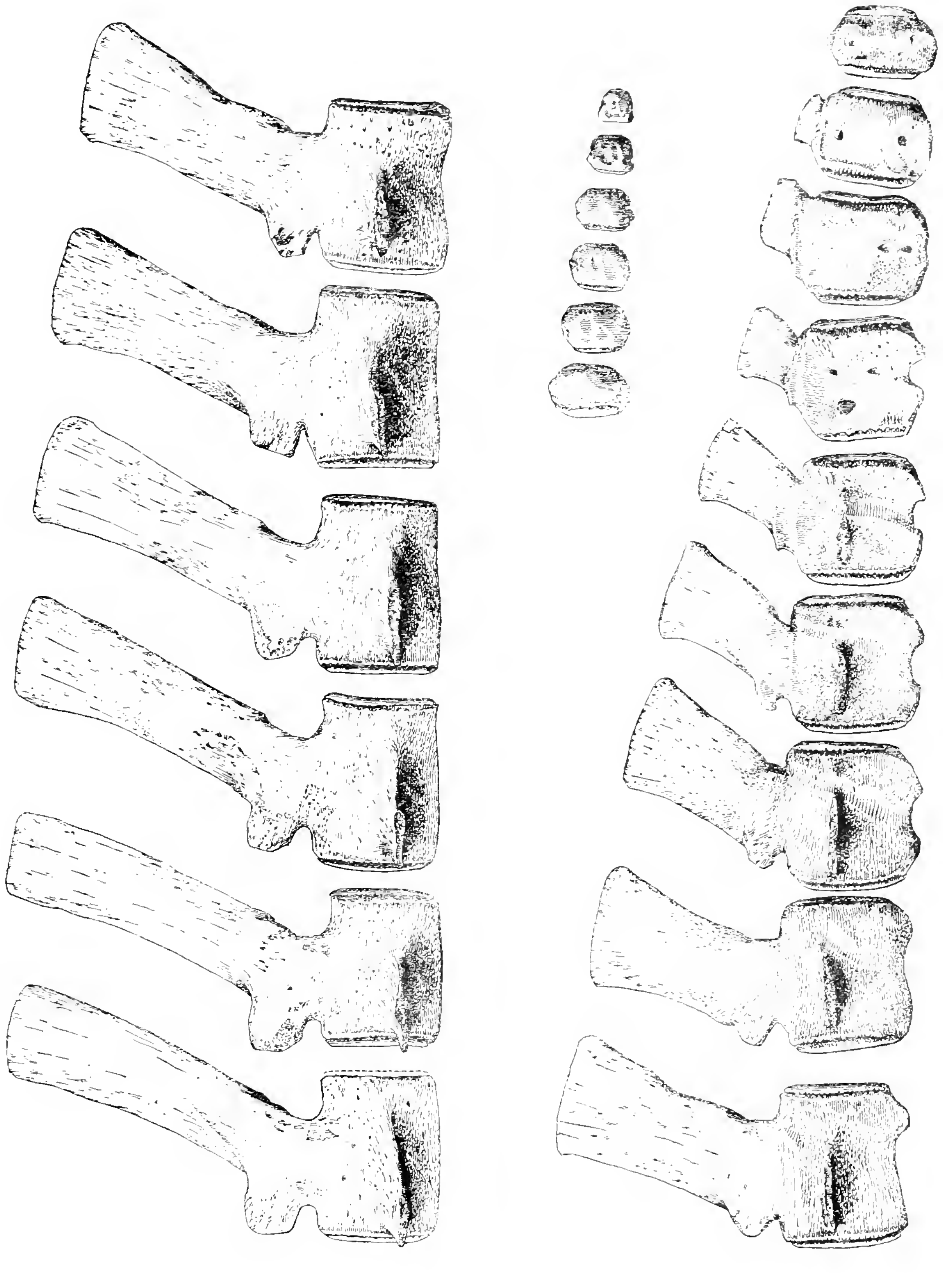


Fig. 6. Lateral view of vertebrae. ($\times \frac{1}{7}$.)

atlas is also larger than that of *H. planifrons*. Otherwise the cervical mass is much alike in both species. Such differences as exist between the South Australian and the Discovery specimens may be regarded as coming within the range of individual variation. The former has the lateral process of the atlas fused with the inferior lateral process of the axis, whereas in the Discovery specimen the inferior lateral process of the axis is distinct. Both specimens show a short rugose superior lateral process on the axis, the South Australian specimen having 'an incomplete foramen on the right and complete foramen on the left between it and the inferior lateral process', whilst the Discovery specimen has this arrangement of foramina transposed. The superior lateral processes of the third to sixth vertebrae are separate and of diminishing size antero-posteriorly in the Discovery specimen. The South Australian specimen has the third ankylosed on the left with that of the preceding cervical.

The neural arch of the sixth is not completely fused with the arches anterior to it, and fusion is less on the left than on the right side. The corresponding arch in the South Australian specimen appears to be completely fused. There is a strong forward-projecting inferior lateral process on the sixth vertebra of the Discovery specimen. Hale (1931) does not mention its presence in the South Australian specimen, and his figure shows that the inferior lateral process of the seventh is of considerable size and prominence and similar to that of the specimen of *H. rostratus* used for comparison with the Discovery *H. planifrons*. The inferior lateral process of the seventh in the Discovery *H. planifrons* is small and inconspicuous. Between it and the superior process is the articular facet for the head of the first rib. The neural arch is free except at the tip, whereas the South Australian specimen has the 'greater part of right side of neural arch free including apex which does not meet the opposite member of the arch'.

Thoracic vertebrae. The Discovery specimen has eight pairs of ribs and therefore eight thoracic vertebrae. As the South Australian animal had nine pairs of ribs the possibility was considered of the ninth pair in the Discovery specimen having been overlooked. However, this is discounted to some extent by the fact that in the La Plata examples eight, not nine, is the number recorded. The reduction to this number represents the extreme reached in any of the Mammalia.

The series of thoracic vertebrae in the Discovery Bottlenose commences with one having a slender neural spine, wide neural arch, widely separated zygapophyses, and short metapophyses at the proximal ends of transverse processes, which last are directed downwards and forwards and bear a facet for the tuberculum of the rib. There is a short centrum bearing a postero-lateral facet for the capitulum of the second rib. Proceeding tailwards the neural spines increase in length and width, the neural arches diminish in size, and the zygapophyses are very much reduced. The metapophyses, from being stout and short, are, in the eighth thoracic laminar, almost semicircular in outline and projecting from the anterior edge of the neural arch. The centrum at the end of the series is about double the length of that of the first thoracic.

The arrangement of the articular facets for the ribs is interesting, and it is unfortunate that the centra of the vertebrae were damaged by the harpoon which killed the animal just at the point where detailed description is most required. However, enough remains to make some sort of interpretation possible. As far back as the fifth thoracic vertebra the articular facets are conspicuous on the postero-lateral edges of the centra. In the sixth vertebra the surface of the centrum on the left side has been obliterated, but the right side which is entire has only the very slightest indication of a facet, whilst the seventh vertebra has a distinct antero-laterally placed facet. It would appear therefore that as far back as the fifth vertebra the capitular articulation is with the rib of the succeeding vertebra, that the sixth is transitional between this arrangement and one in which the capitulum of the rib articulates with the centrum of the same vertebra with which the tuberculum is associated, and that in the seventh this process is almost complete, with capitulum and tubercle of the seventh rib having articulation almost completely restricted to the seventh thoracic vertebra.

The change in position of the transverse process from the side of the neural arch (upper transverse process of Flower, *Osteology*, 1870, p. 60) to the side of the centrum (lower transverse process of Flower, op. cit.) takes place in the eighth vertebra. There is not in the Discovery specimen as in the South Australian specimen a vertebra showing the transition from the one to the other kind of transverse process. The *H. rostratus* specimen used for comparison with *H. planifrons* showed in the eighth vertebra a condition intermediate between that of the other two specimens. In it the upper transverse process is in the form of a small knob-like and quite vestigial process on the lower margin of the metapophysis.

Going tailwards the ventral surface of the centrum shows increasing development of the median ridge which is in the form of a well-defined keel on th. VIII.

Lumbar vertebrae. There are eleven vertebrae in the lumbar series of the Discovery *H. planifrons*. The South Australian specimen has one less, but this discrepancy may be accounted for by the greater number of thoracic vertebrae in the latter specimen.

The neural spines increase in length to about the middle of the series and then diminish gradually, so that a line joining their extremities makes a very shallow arc. There is an increasing inclination backwards of the spines going tailwards, a widening of the spine as a whole and of the distal end as well in the more posteriorly situated elements. The metapophyses are laminar, have rounded margins, and show increasing approximation to each other. The neural canal diminishes in size; the centrum increases so that at the end of the series it is about 1½ times the length of the first lumbar; the diameter also is increased. The transverse processes are directed obliquely forward, flattened, beginning to diminish in length, and get wider at the tail end of the series. The first lumbar transverse process is somewhat different from those that succeed it, being disproportionately broad and rather stouter.

The hypophysial ridge is of increasing definition to about the middle of the series, whence it diminishes in prominence; and in the last lumbar it is a low, flattened, inconspicuous keel.

No obvious differences distinguish the vertebrae in this region from those of *H. rostratus*.

Caudal vertebrae. The caudal series of vertebrae is incomplete in the Discovery specimen. Seventeen remain and the missing elements are at the posterior end. The South Australian specimen has 20 caudals.

The neural spines diminish tailwards and disappear after the tenth caudal. In lateral view they are broad distally with a slight narrowing towards the neural canal. There is a corresponding diminution of metapophyses which anteriorly in the series are laminar with rounded border, and posteriorly are rather stout short tubercles which finally disappear. The neural canal continues the diminution in size observed in the lumbar series.

Anteriorly the centra have the massiveness which characterizes the more posteriorly placed lumbars and, going tailwards, although length diminishes gradually, the decrease in transverse diameter is not noticeable until near the end of the column where the diminution becomes more marked and the vertebrae adopt a subcuboid shape unlike the cylindrical form of the more anterior elements.

The transverse processes disappear as distinct prominences after the seventh caudal. While still distinguishable they maintain the obliquely forward direction noted in the lumbar vertebrae. The perforation of the transverse process of the seventh, noted by Dale, is represented in the Discovery specimen by a pronounced emargination of the outer edge of the process on each side near its posterior end. This is visible, although much less obvious, on the transverse processes of two vertebrae immediately anterior to the seventh caudal.

On the lower surface of the centrum anteriorly and posteriorly are the paired facets for the chevron bones. Two longitudinal ridges with concave margin join the anterior to the posterior facets. The concavity is ill defined at the anterior end of the series, and is correlated with the lesser prominence of the facets themselves; but going tailwards with the greater development of the articular surfaces and the shortening of the length of the mass of the centrum, the emargination becomes increasingly pronounced until on the ninth (in both the South Australian and the Discovery specimens) a foramen is enclosed.

CHEVRON BONES (Fig. 7)

The nine chevron bones figured are an incomplete series; at least one is considered to be wanting. However, those remaining give an adequate idea of the form these bones assume in *H. planifrons.*

Fig. 7. Chevrons. (× ⅐.)

Only one side of the first chevron is present, a slender lamina of bone which has no evidence of having been fused to the element of the other side. The second chevron, a single bone, has a broad, short, spinous process with obliquely rounded ventral margin. The third has the spinous process greatly elongated with rounded antero-ventral margin, and with hinder and ventral margins meeting at roughly a right angle. From the third tailwards there is a progressive diminution in the spinous process length and a reduction in size of the bone as a whole, in the last of the series the spinous process being only about one-half as long as it is wide. The chevrons show no distinctive difference from those of the South Australian specimen or of *H. rostratus.*

RIBS (Fig. 8)

The Discovery *H. planifrons* has eight ribs on each side, in this number agreeing with the La Plata Museum specimens. The South Australian specimen has nine pairs of ribs, the ninth pair being small, asymmetrical and obviously vestigial. *H. rostratus* normally has nine pairs of ribs also, but at least one specimen in the British Museum collection has only eight pairs.

In the Discovery specimen the first pair of ribs is short, broad, flattened and with sternal end directed at a slight angle forward from the remainder of the shaft of the bone. The second rib is moderately broad, more elongated than the first and without forward trend of the distal end. The third to the sixth are similar to each other, long, slender and subequal in length. In the seventh, shortening of the shaft has become pronounced, but otherwise the essential features of the four preceding ribs are maintained. The eighth is still shorter, and in the absence of a capitular portion is distinguished from all the ribs that precede it.

The first seven ribs have the capitulum defined to a greater or lesser degree. In the first the capitulum and tubercle are almost confluent, in the following five the capitulum is situated at some distance from the tubercle. In the seventh the tubercle and capitulum approximate again and the eighth, as just stated, has no capitulum.

STERNUM (Fig. 9)

The sternum consists of three elements, the largest of which is the manubrium. The manubrium is roughly rectangular in outline. The anterior emargination is semicircular and not so pronounced as in the South Australian specimen. There is a small posterior notch, and the bone extends tailwards on the right side of this to a greater extent than on the left. Asymmetry is also displayed on the lateral margins. The facets for the first pair of sternal ribs are equally prominent, but whereas the right side bears a facet a little way posteriorly to the first there is no corresponding one on the left. The external surface of the bone is convex and the internal concave.

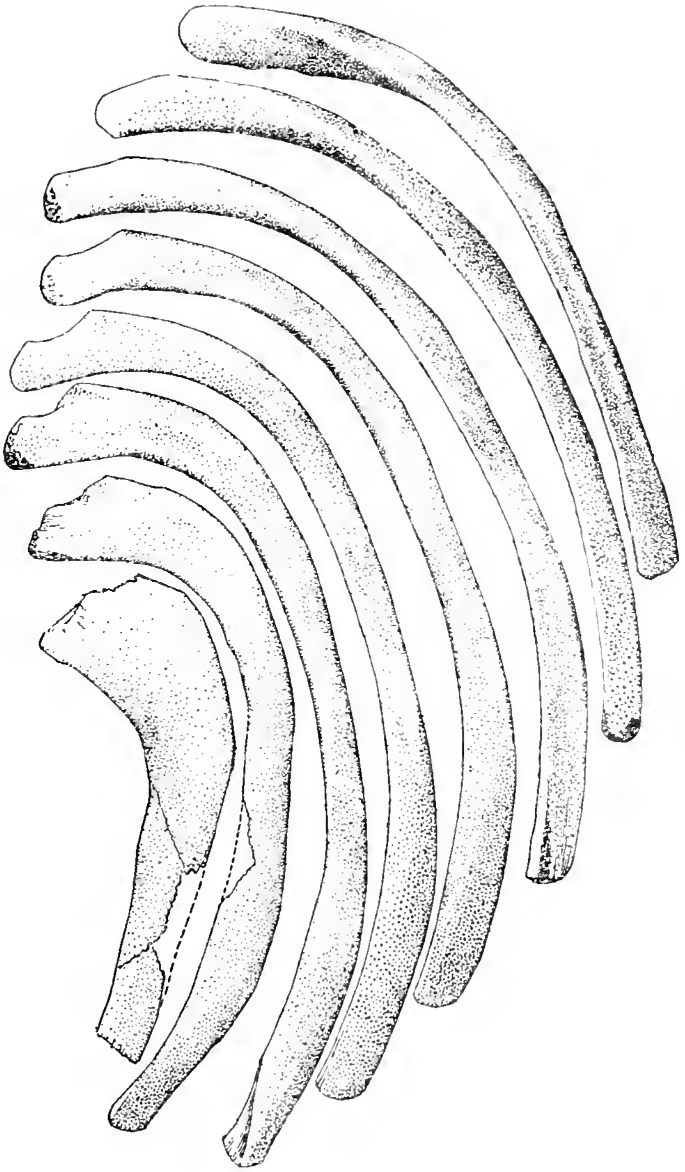


Fig. 8. Ribs. ($\times \frac{1}{7}$.)

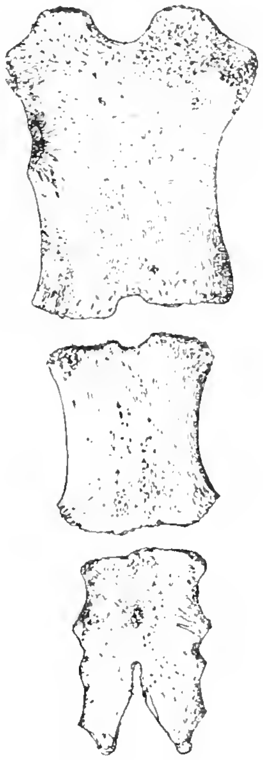


Fig. 9. Sternum. ($\times \frac{1}{7}$.)

Anteriorly, the second sternal element has a median notch, on the right side of which the anterior margin is a little way behind that on the left side. This asymmetry is repeated on the posterior margin, in which, however, the notch is wanting. The lateral margins are shallowly concave, and at the antero- and postero-lateral corners are facets for the appropriate sternal ribs.

The last sternal bone has again an uneven anterior border, the left side being in advance of the right. It is without anterior notch. The posterior margin has a deep, angular notch extending nearly to the middle of the bone; in the South Australian specimen it is wide and shallow. There are three facets on each side for sternal ribs, one at each antero- and postero-lateral corner and one midway between these.

The ventral surface of the bone is raised into a low, ill-defined tubercle.

SCAPULA (Fig. 10)

Both the scapulae of the Discovery specimen are damaged posteriorly. Anteriorly the evenly convex dorsal margin meets the straight anterior margin at almost a right angle, not being broadly rounded as in the South Australian specimen. The acromion, as in the latter specimen, is bent upwards and inwards, the superior and inferior margins being parallel to each other and the distal margin rounded. It is shorter than in the South Australian specimen. The coracoid is without the distal expansion noted in the South Australian specimen, but is otherwise similar in position and shape.

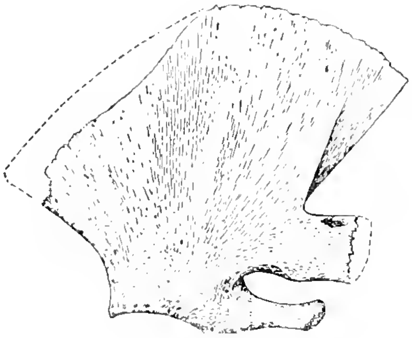


Fig. 10. Scapula. (× $\frac{1}{7}$.)

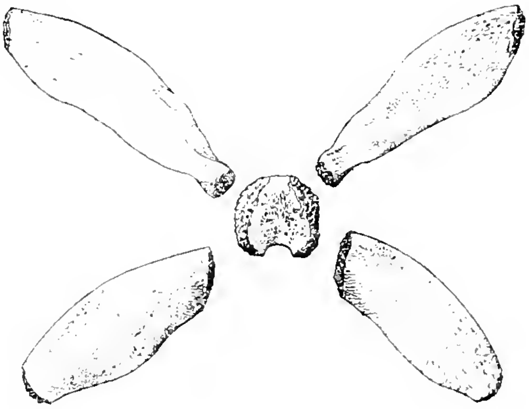


Fig. 11. Hyoids. (× $\frac{1}{7}$.)

HYOIDS (Fig. 11)

The thyro-hyals are not fused to the basi-hyal. The basi-hyal has a short, straight anterior margin and deeply concave posterior margin. The lateral portions of the bone which are convex are rugose, and are completely occupied by the facets for connexion with the thyro-hyals.

The thyro-hyals are wing-like in shape, and stoutest at their proximal ends where there is a broad area for attachment to the basi-hyal. The bones diminish in thickness from the anterior to the posterior border, where the upper and lower surfaces meet in a ridge at a very acute angle. The distal tips of the thyro-hyals are truncated and rugose.

The tympano-hyals are elongate, flattened and tapering at each end to a truncated rugose tip. The thickness of the bone diminishes from the front to the hinder margin, which last has a fairly acute edge.

APPENDIX

(1) A male specimen of *H. planifrons* was measured and examined by Dr L. Harrison Matthews, at Leith Harbour, South Georgia, on 3 January 1927. It was intended that the skeleton should be preserved, but before it could be despatched to England an avalanche, which obliterated part of the whaling station, buried the specimen, and it was not recovered.

The external measurements recorded by Dr Matthews are as follows:

	m.
Total length, tip of snout to notch of flukes	4·63
Projection of lower jaw beyond tip of snout	Nil
Tip of snout to blowhole	0·74
Tip of snout to angle of gape	0·85
Tip of snout to centre of eye	0·76
Tip of snout to tip of flipper	1·72
Notch of flukes to posterior emargination of dorsal fin	1·27
Width of flukes at insertion	0·39
Notch of flukes to centre of anus	1·33
Notch of flukes to umbilicus	2·46
Centre of anus to centre of reproductive aperture	0·38
Vertical height of dorsal fin	0·25
Length of base of dorsal fin	0·37
Axilla to tip of flipper	0·42
Anterior end of lower border to tip of flipper	0·51
Length of flipper along curve of lower border	0·55
Greatest width of flipper	0·17
Length of severed head from condyle to tip	0·697
Greatest width of skull	0·369

The following notes were also made:

Colour	Black dorsally shading to grey ventrally
External genitalia	Normal
External parasites	None
Hair	None
Ventral grooves	Two grooves on the throat, one on each side situated under the ramus of the mandible, 22 cm. in length
Blubber	5 cm. thick on the side below the dorsal fin
Palate	Grey
Tongue	Flesh-pink
Food	Stomach contained a few crystalline lenses from the eyes of cephalopods
Internal parasites	None seen
Mammary slits	Each 4 cm. in length, situated 12 cm. anterior to the anus

(2) Mr A. G. Bennett, at one time naturalist to the Government of the Falkland Islands, has provided another record of the occurrence of *H. planifrons.* He obtained photographs of a specimen killed in the vicinity of the South Orkney Islands in January 1915.

One of the photographs, in which the carcass is floating in the water alongside the factory ship, shows the surface of the skin scored by numerous irregular marks. Similar streaks have been noted in other ziphoids and are presumed to be the teeth marks of other individuals of the same species. In addition to these elongated scratches one or two oval marks can be seen. They are reminiscent of the scars described and figured by Mackintosh and Wheeler (1929) as occurring in various members of the whalebone whales. Other features which can be observed in the photograph are the pronounced 'forehead' which rises at almost a right angle from the well-defined beak; and the right flipper which is of typical ziphoid form, having a very shallowly convex lower border and slightly more convex upper edge.

A second photograph gives a ventro-lateral view of the anterior portion of the body, lying on the deck of the whaling vessel. The region of the mouth and throat, as far back as the two ventral grooves is of a much lighter colour than adjacent portions of the body. The 'forehead' appears to be quite darkly pigmented. The rostrum is stout and well defined and the upper and lower lips meet in a line which anteriorly is horizontal but farther back swings obliquely upwards.

ACKNOWLEDGMENTS

I have to thank Dr L. H. Matthews and Mr A. G. Bennett for the information and assistance they have given me. The figures illustrating the paper are the work of Col. M. St L. Simon, and it is with pleasure that I acknowledge my indebtedness to him, and to my colleague W. H. T. Tams, Esq., who took the photographs from which the figures of the axial skeleton were executed by Col. Simon. I have also to thank Mr E. J. Manly who has helped me with the compilation of the report.

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REPORT ON ROCKS FROM WEST ANTARCTICA AND THE SCOTIA ARC

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(Text-figs. 1-14)

FOREWORD

By J. M. WORDIE, M.A.

In the second volume of *Das Antlitz der Erde* published in 1888, and again in more detail in the final volume in 1909, E. Suess put forward the view 'that the Andes are to be seen again in Graham Land'. By this dramatic phraseology he implied that the folded mountain border of the Pacific, as exemplified in the Andes, swings eastward from Tierra del Fuego to South Georgia and then curves back from the South Sandwich Islands through the South Orkneys to Graham Land and the South Shetlands. Suess based his views on a memoir by H. Reiter in 1886,[1] who there gave substance to an idea put forward as far back as 1831 by Sir John Barrow.[2] Suess characteristically gives the credit for these arguments to Reiter, whose paper I have not seen, but it is not unlikely that it was Suess himself who suggested this work; the first volume of the *Antlitz* had appeared in 1885, and there can be no doubt but that the ideas of the second volume would already have formed themselves in the author's mind, and this was a problem which required to be examined. Andersson, in his *Geology of Graham Land*, in fact mentions that Reiter had been stimulated by Suess's first volume. In the interval between Suess's first statement in 1888 and his more detailed advocacy in 1909, Dr Otto Nordenskjöld led the Swedish Antarctic Expedition to the east coast of Graham Land in 1901-3, and J. Gunnar Andersson who was with him published his important *Geology of Graham Land* in the *Bulletin of the Geological Institute of Upsala*, vol. VII, Upsala, 1906. Nordenskjöld himself was also much alive to the problem and has both described the rocks, *Petrographische Untersuchungen aus den Westantarktischen Gebiet*, Upsala, 1906, and also put forward an authoritative statement of the whole problem in *Handbuch der Regionalen Geologie: Antarktis*, Heidelberg, 1913. Nordenskjöld and Andersson carried out in the field what Reiter had sensed in the study. Andersson, Nordenskjöld, and Suess together may therefore be regarded as the main advocates of 'two groups of Antilles'. 'South Antilles' was the name first given to the islands of the southern arc; but more recently the sea enclosed by these islands has been named the Scotia Sea, and the name South Antillean Arc has now automatically been replaced by the more appropriate title of Scotia Arc.

Andersson and Suess could base their arguments only on imperfect data, some of which are now known to be incorrect. Since then many new rock specimens have been obtained and worked on by qualified geologists. The activities particularly of the Discovery Committee have succeeded in providing collections surpassing all previous material. Dr Tyrrell has already dealt with some of the collections in earlier papers on South Georgia, the South Sandwich Islands and the South Shetlands; and in the present memoirs he is at last able to make authoritative statements on the remaining portions of the arc either scantily known or completely unexplored at the time when Suess made his great analysis of the plan of the Earth.

[1] H. Reiter, *Die Südpolarfrage und ihre Bedeutung für die genetische Gliederung der Erdoberfläche*, Weimar, 1886.

[2] Sir John Barrow, *Journal of the Royal Geographical Society*, vol. I (1832), p. 62.

Dr Tyrrell's main conclusions are as follows:

Two dredgings were made from 'Discovery II' in the neighbourhood of the Shag Rocks in November 1930. Of the nineteen specimens obtained fifteen are described as tremolite-epidote-greenstone or greenstone-schist. This is an important find, as it can be paralleled both with rocks from Clarence Island and with specimens from Tierra del Fuego.

Fresh material has been obtained in the South Sandwich Islands both *in situ* at Saunders Island and from dredgings elsewhere in the group. These rocks are all volcanic in origin and of Recent age. The new material, along with earlier collections, shows that the South Sandwich rocks have more in common with rocks from the Antilles of North America than with any specimens so far known from the Andes. Dr Tyrrell considers that the South Sandwich Islands probably lie on a ridge parallel to, but east of, the main Scotia Arc.

Elephant Island and Clarence Island and others east of the main South Shetland Islands not only lie at some distance from the South Shetlands proper but also differ from them geologically. A greenstone-greywacke-mudstone association is present, such as is formed in the geosynclinal stage of a mountain-building cycle and is affected as would be likely by low-grade metamorphism. Assemblages of this character are found not only in the Elephant and Clarence Group but also in the South Orkneys. They are paralleled near Ushuaia in Tierra del Fuego, and a somewhat similar assemblage occurs in South Georgia. Dr Tyrrell considers that these types may also be expected to form the at present unknown rock basement of Graham Land.

There are extensive collections from the South Shetlands which modify earlier conclusions. The occurrence of sediments of presumed Mesozoic age on certain of the islands has apparently been over-emphasized, and one should now regard the South Shetlands as of preponderatingly volcanic origin, made up either of lavas, mainly andesites, dacites and rhyolites, or of their associated tuffs, breccias and agglomerates. Plutonic rocks may, however, be commoner than so far supposed. There were two lava periods, and the intrusive rocks, such as the diorite on King George Island, are regarded as the underground equivalents of the later period. The Recent volcanoes along Bransfield Strait are still younger than either of the above lava periods, and it is even probable that Deception Island and Bridgeman Island have been active in historic times. The chemical characters of the Deception Island lavas indicate a soda-rich andesite, not readily paralleled in the Andes. Elsewhere the andesites and basalts are of normal circum-Pacific, that is to say undoubted Andean, type.

Finally, a fifth section deals with some specimens from Graham Land. These are less numerous as a collection, but they include a quartz-porphyry formation at Adelaide Island of the same nature as the rocks of a belt 400 km. in length already known from Patagonia.

No new rocks are to hand either from the South Orkneys or from South Georgia. Both localities are now well known. The importance of the new material lies in the nature of the rocks themselves, and Dr Tyrrell, in these five papers, has provided petrographic arguments for what was up till now not more than a matter of inference. The petrographic evidence is more or less complete. To settle the actual line of the Arc, however, requires that the bottom contours should be better known. Soundings over a wide area are much to be desired, and will decide whether there is a single arc or a series of concentric curves. Meantime one can safely say that Suess's, Andersson's and Nordenskjöld's arguments no longer relate merely to a possibility, and that Suess's vision of the Pacific structure advancing into the Atlantic must now be regarded as firmly established.

PART I. PETROGRAPHY OF THE SOUTH SHETLAND ISLANDS

INTRODUCTION

This work is based on two collections of rocks, made during the third and fourth commissions of the 'Discovery II' in 1934 and 1937 respectively. The specimens were accompanied by excellent geological and geographical notes, those of 1934 by Dr N. A. Mackintosh, and those of 1937 by J. W. S. Marr, M.A., B.Sc. Relevant points from these notes have been incorporated, with appropriate acknowledgement, in the following descriptions.

Bibliography. A full bibliography of the earlier literature relating to the geology and petrography of the South Shetland Islands (and adjacent lands) is given in my paper listed as (1) below. Only papers which have been published since 1920 are given in the following list:

(1) G. W. Tyrrell. 'A Contribution to the Petrography of the South Shetland Islands, the Palmer Archipelago, and the Danco Land Coast, Graham Land, Antarctica.' *Trans. Roy. Soc. Edinb.* LIII, pt. 1, 1921, pp. 57–79.

(2) H. H. Thomas. 'On the Innes Wilson Collection of Rocks and Minerals from the South Shetland Islands and Trinity Island.' *Ibid.* pp. 81–9.

(3) O. Holtedahl. 'The Geology and Physiography of Some Antarctic and Sub-Antarctic Islands.' *Scientific Results of the Norwegian Antarctic Expeditions*, 1927–28 *and* 1928–29, *instituted and financed by Consul Lars Christensen*, No. 3, Norske Vidensk.-Akad., Oslo, 1929, 172 pp.

(4) T. W. F. Barth and P. Holmsen. 'Rocks from the Antarctandes and the Southern Antilles (Being a Description of Rock Samples collected by O. Holtedahl, 1927–28, and a Discussion of their Mode of Origin).' *Ibid.* no. 18, 1939, 64 pp.

General. The South Shetlands comprise a group of ten large and small islands extended in a north-east to south-west direction parallel to, and at a distance of from 60 to 70 miles from, the coast of the Graham Land peninsula, from which they are separated by Bransfield Strait. From north-east to south-west the islands are Bridgeman Island, King George Island, Nelson Island, Roberts Island, Greenwich Island, Livingston Island, Deception Island, Snow Island, Smith Island, and Low Island. Of these, practically nothing is known of the two last-named. Deception Island, a sea-flooded Recent crater, is the best known. Bridgeman Island, too, is a Recent volcano and may, like Deception Island, have been in comparatively recent eruption. Mr Marr's notes make it clear that Penguin Island, off the eastern horn of King George Bay in King George Island, is also a Recent volcano comparable with Deception Island and Bridgeman Island.

The rock specimens collected during the recent Discovery II expeditions number in all 141, of which 81 come from King George Island, 19 from Deception Island, 17 from Roberts Island, 16 from Livingston Island, 4 from Nelson Island, and 4 from Snow Island.

The plan of the present paper is to describe the collections from each of these islands in turn, incorporating as much of the geology as can be gleaned from the field notes made by Dr Mackintosh and Mr Marr. The chemistry of the igneous suite will then be studied with the aid of previously published and two new analyses, and finally a conspectus of the geology of the South Shetlands will be attempted from the material now available.

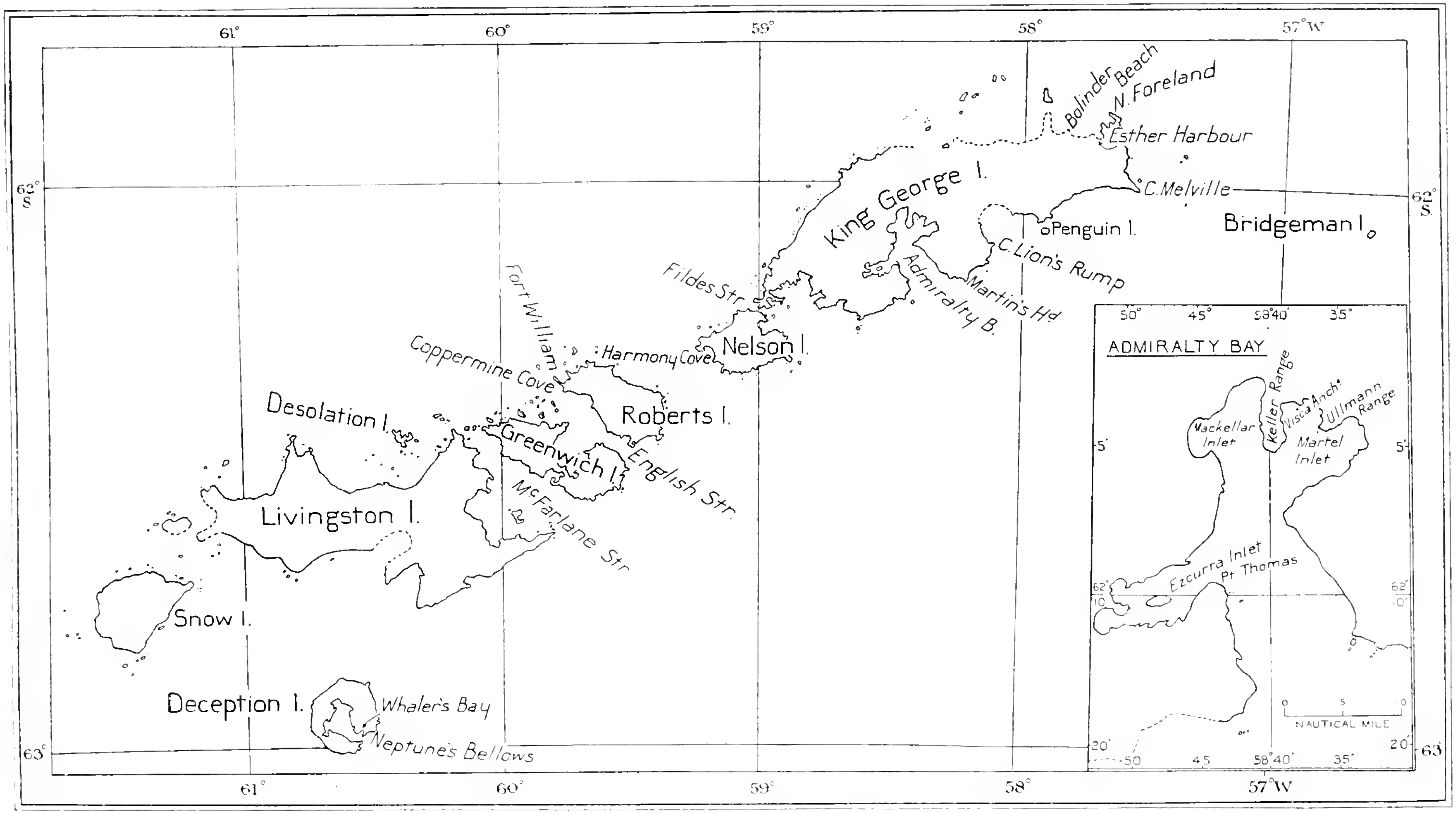

Fig. 1. The South Shetland Islands.

PETROGRAPHY

KING GEORGE ISLAND

Admiralty Bay. The Ullmann Range, a ridge trending north and south, projects into Martel Inlet (north-east arm of Admiralty Bay) and forms the eastern side of Visca Anchorage. Specimens were collected from the western side of this ridge. In his notes, Dr Mackintosh has given an excellent sketch of the Ullmann Range as seen from Visca Bay, and has called attention to a prominent dike which climbs the scarp and culminates in a sharp pinnacle near the central point of the ridge. This view is undoubtedly the subject of Mr Ferguson's fine photograph (Ferguson, *op. cit.* pl. iii, fig. 1),[1] which clearly shows the dike and a series of lava scarps to the left (north) of it.

The dike consists of a highly porphyritic pyroxene-andesite with phenocrysts of plagioclase (basic andesine, Ab_{55}), yellow augite, and chloritic pseudomorphs after orthorhombic pyroxene, in order of abundance. There are also some large irregular masses of magnetite. The ground-mass is fine-grained, but apparently holocrystalline, although somewhat altered. It contains a little quartz.

The lavas of which the Ullmann Range is composed are represented by several specimens mainly collected from screes. Alongside the dike occurs a trachytic lava with a very dense fluxional ground-mass, consisting of minute feldspar microlites, apparently orthoclase, in a cryptocrystalline base. There are numerous small phenocrysts of soda-orthoclase and a plagioclase which is now mostly albite, but the presence of epidote suggests that it may originally have been a more calcic variety. The rock also carries numerous euhedral crystals of ilmenite rimmed with a leucoxenic alteration product. Traces of ferromagnesian minerals are present, but are altered beyond recognition. This rock is notable in containing a few crystals of pale blue pleochroic apatite.

A coarser textured specimen provides further data. The ground-mass is seen to consist of laths of orthoclase mingled with oligoclase, and contains visible quartz. Still another specimen consists of an angular breccia of fragments similar to the above. Many of the fragments are rich in quartz. The shapes of some pseudomorphs outlined in iron ores suggest that the ferromagnesian mineral in these rocks may have been hornblende.

These lavas may be provisionally classed as dacite or quartz-latite according to the amount of quartz or orthoclase present. Similar types have been described from Admiralty Bay by the author ((1), p. 71). They also occur in the Fildes Strait area (p. 44).

Near the beach on the western side of the Ullmann Range was collected a lava which may be described as an altered quartz-andesite. It contains phenocrysts of plagioclase badly carbonated, and chloritized pseudomorphs after pyroxenes. Quartz is comparatively abundant, but is partly of secondary origin. Bluish apatite crystals are abundant, and the lava is therefore regarded as belonging to the same series as those described above. From the screes to the south of this point a silicified and pyritized volcanic tuff was collected.

Mr Marr collected three specimens from the western side of the Keller Range along the eastern shore of Mackellar Inlet. He describes this coast as consisting of slopes of reddish brown tuff with frequent outcrops of lava which are also prominent at sea level. While two of his specimens are so highly carbonated and silicified that they can only be described as altered andesites, the third, which is stated to have come from a fan-shaped columnar outcrop, is less altered, and can be described as pyroxene-andesite. Feldspar phenocrysts are numerous and, although badly carbonated, can be identified as plagioclase of composition about $Ab_{60}An_{40}$. The ferromagnesian constituent consists of chloritized pseudomorphs after pyroxenes, usually found in crystal clots along with feldspar, ilmenite, and large crystals of apatite. The ground-mass is dense, brown, and cryptocrystalline, the only identifiable constituent being feldspar microlites showing straight extinction (? oligoclase).

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[1] For full reference see p. 76.

Two specimens were collected by Mr Marr from near Point Thomas, Admiralty Bay. One, from the coast a little south of the Point, is a fresh hypersthene-andesite. This rock appears to be identical with the rock called hypersthene-augite-bandaite of the volcanic vent of Three Brothers Hill, Potter's Cove, Fildes Strait, described by the author ((1), p. 68) from Mr Ferguson's collection, and the reader is referred to this full description for petrographical details. In fact, Mr Ferguson actually collected material from the same area ((1), p. 69). The extreme freshness of this rock, as compared with the extensive alteration suffered by the lavas from the interior of Admiralty Bay, suggests that it belongs to the later of the two volcanic episodes on the mainland of King George Island.

On the other hand, the rock collected by Mr Marr from the coast of Ezcurra Inlet, one mile west of Point Thomas, is an altered pyroxene-andesite which clearly belongs to the older series of lavas. This occurrence suggests that the boundary between the older and newer series of lavas should be drawn a little farther south than is shown on Mr Ferguson's map (D. Ferguson, *op. cit. supra*, fig. 2, p. 38).

Fildes Strait. Fildes Strait separates King George Island from Nelson Island to the west. Dr Mackintosh collected several specimens from a harbour (St. 1482) near the south end of the strait, which may be identical with the 'Potter's Cove' of Mr Ferguson, or it may be the 'Marian Cove' of the same author which is a little farther north. Dr Mackintosh describes the rocks as much weathered, breaking down into screes through which solid rock appears here and there.

Three of the specimens from this locality are dark, very compact rocks of basaltic type. They consist mainly of a very fine-grained ground-mass of intersertal type with numerous microlites of a striated feldspar giving extinctions up to 20° (andesine), scattered patches of chlorite and obscure brownish material probably representing pyroxenes, and particles of haematitized iron ore embedded in a reddish cryptocrystalline or glassy base. The few small phenocrysts consist of epidotized plagioclase (originally labradorite), and, in one section, fresh, euhedral, colourless augites of small optic axial angle (? pigeonite). A chemical analysis (p. 59) shows that these rocks must be regarded as of tholeiitic composition.

One specimen from this locality, however, is much more acid than the above, and must be classed as soda-rhyolite or quartz-keratophyre. It is a whitish felsitic rock much reddened by haematitic staining. In thin section it is seen to consist of a dense quartzo-feldspathic ground-mass with an obscure hint of spherulitic structure, which carries numerous large phenocrysts of turbid albite and haematitized biotite.

A single specimen was collected from another locality on Fildes Strait near the narrow northern entrance (St. 1483). Dr Mackintosh states that the rock formation here appeared to be quite different from that of St. 1482, an observation which is confirmed by examination of the specimen. One adjacent islet consisted of a dome-shaped mass of rock, 'probably basalt', with a pronounced columnar structure, but the outcrop from which this specimen was collected was not columnar.

This rock turns out to be a feldspathic olivine-basalt or olivine-andesite. Large phenocrysts of fresh basic labradorite (Ab_2An_3) are very abundant. Calcified and serpentinized olivines are numerous, but a fresh pale augite is quite subordinate in amount. These are embedded in an intergranular ground-mass consisting of plagioclase laths, augite and iron-ore granules, and a dark cryptocrystalline base.

North Foreland District. The North Foreland is the tip of a long narrow peninsula springing from the north-eastern corner of King George Island. A shorter peninsula ending in a steep bluff headland called Brimstone Peak occurs a mile or two to the west, and the two peninsulas enclose a deep bay. Still farther west comes the well-known Esther Harbour, which was apparently not entered on this occasion. This district (St. 1949) was visited by Mr Marr.

Mr Marr writes that 'the cliffs forming the west side of the Foreland... are composed of a massive grey rock much traversed by cracks and joints, giving it a very shattered appearance'. This is borne out by the three specimens collected here, which are all parts of a plutonic igneous rock of variable grain size. This may be described as quartz-hornblende-pyroxene-diorite, and represents a very abundant type in West Antarctica ((1), p. 61). Its three principal minerals are plagioclase (core andesine; outer shell oligoclase); pale green hornblende, sometimes with a pale brown tint; colourless diopsidic pyroxene which is altering into a pale green amphibole. The accessory minerals are quartz, filling the interstices between the main constituents; some large flakes of reddish biotite; abundant ilmenite altering to leucoxene; and a considerable amount of apatite. The amphibole and pyroxene tend to form well-shaped crystals, and to enter into clots with biotite and ilmenite. One of the specimens is a true plutonic type with allotriomorphic texture and comparatively coarse grain. Another is a fine-grained aplitic type poorer in the mafic minerals, which may be styled quartz-microdiorite; and the third is a porphyritic type in which the feldspars, hornblendes and pyroxenes (including both augite and hypersthene) occur as phenocrysts in a fine-grained granulose ground-mass. A few large crystals of bluish apatite occur in this rock. This type may represent a chilled marginal phase of the intrusion.

It is clear that the vicinity of North Foreland is occupied by a large plutonic intrusion of the same type as occurs at Noel Hill, Marian Cove ((1), p. 61), and at Le Poing on the west side of Admiralty Bay ((1), p. 62). This mass may occupy the whole of the eastern side of King George Island, as Mr Marr states that the cliffs to the east and south of the Foreland, and probably as far as Cape Melville, are high and sheer, and seem to consist of the same grey massive rock.

Brimstone Peak is said to be composed of perpendicular 'basalt' cliffs rising sheer out of the sea to a height of 150 ft. The single specimen obtained from this locality shows, however, that the rock is a fresh hypersthene-augite-andesite of the Recent type so common elsewhere in King George Island. The hypersthene is mostly altered to chlorite or bastite, and often forms the core of an augite crystal. A single crystal of magnetite-rimmed brown hornblende was present in the thin section.

Bolinder Beach (St. 1953) is situated a few miles west of Esther Harbour and Brimstone Peak. It is described by Dr Ommanney as a bluff peak crowned by three buttresses of dark grey and light brown rock veined by what, on closer examination, proved to be finely crystalline rose and amber quartz. All the rock specimens collected here were lost in a boat accident except a few from a 100 ft. cliff at sea-level on the northern face of the bluff.

This rock proves to be an enstatite-andesite of micro-porphyritic and intersertal texture, consisting of very numerous feldspar laths (andesine, Ab_3An_2), and less abundant pseudomorphs in chlorite after enstatite (typical square prisms with truncated corners), in a dense, brown, cryptocrystalline to glassy ground-mass. It probably belongs to the older series of lavas, as it is intersected by mineral veins which may represent the same group of veins (quartz and pyrites) as that described by Ferguson from the islands of Esther Harbour (*op. cit. supra*, p. 41). These veins run nearly east and west, and might thus probably intersect the region of Bolinder Beach.

Penguin Island and Adjacent Mainland. Penguin Island is situated off the eastern horn of King George Bay. That Penguin Island is a Recent volcano, one of the line of volcanoes fringing Bransfield Strait, is Mr Marr's important and most interesting discovery. The following is a description of Penguin Island quoted from Mr Marr's report:

> The southern half of Penguin Island is a volcanic cone. The northern half consists of a long, very low plateau, much of it only about 50 ft. high. The western face of the cone is steep and has a deep brick-red tint. On its south-eastern and eastern sides the cone slopes down to a plateau roughly 100 ft. high, which is continuous in a wide sweep with the lower plateau which forms the northern half of the island. On the southern side the cone ends

abruptly in sheer and inaccessible cliffs from 50 to 100 ft. high which continue round the coast to the eastern side of the island. The rock is lava, at a distance dark in colour, and much broken with cracks and fissures.... The island is remarkably free of snow and ice, and although snow may lie thinly on it after a heavy fall it does not remain for long. [This fact strongly suggests that there is still much residual heat in the cone, and that it may only be dormant.]

Penguin Island is a volcanic cone in the shaping of which three, and perhaps four, periods of activity seem to have been involved. What seems to have been the earliest and biggest eruption is represented now by the concave section of a very large, but almost entirely cut away crater which occupies nearly the whole of the western face of the cone, from the shingle beach up to the summit. The degree of concavity is not very high, yet it is unmistakable. The sides of the interior of this now almost destroyed cone are composed of rather finely divided volcanic clinker of a rich brick-red colour which gives this side of the island its characteristic tint. The clinker fragments have the even consistency of a coarse gravel. Projecting out of this eroded crater, its base on a level with the beach, is a huge plug [? dike] of lava from three to five feet in width and rising vertically like a wall for nearly a hundred feet. Similar though less conspicuous plugs [dikes] occur elsewhere in this crater.

Main summit crater. A later eruption is perhaps represented by this crater, a third of a mile across and about 200–300 ft. deep, which occupies the summit of the cone. Evidently the rim of this crater has crumbled away considerably, for it is highest to the north, but slopes downward towards the south (see sketch, Fig. 2). The bottom is rather damp and shows signs of there having been water lying about. On the east side of the interior of the bowl a gigantic plug of lava sticks up vertically for about 100 ft., the top, however, not projecting beyond the rim of the crater. There is some quite deep snow, which is possibly permanent, inside the bowl on its north-east side.

The western side of Penguin Island from the anchorage near the Lion's Rump: note the sloping rim of the summit crater.

geofmath
7.1.37

Fig. 2. Penguin Island.

Another eruption, subsequent to that which produced the main summit crater, is represented by the small secondary cone which rises concentrically from the bottom of the former. The secondary cone is about 100 ft. high and has a crater less than 80 yards across at the rim, and about 20 ft. deep.

Ash beds. Much of the lower part of the cone, and a large part of the 100 ft. plateau to the south-east and east of it, seem to be composed of horizontally stratified ash beds of a light colour.

The coastal cliffs throughout are composed of lava often broken by cracks and fissures. On the eastern side of the island the crests of the cliffs are extremely rugged and often twisted into grotesque shapes, evidently the result of cooling in the surface of an ancient lava flow. At the south-west corner of the island a certain warmth was felt on the lava and inside a fissure. The heat experienced was very slight, but we were of the opinion at the time that it was unlikely to have been due to absorption from the sun.

Crater on east side. On the east side of the island, some 60–80 yards from the coast, another old crater occurs in the 100 ft. plateau. Its rim is flush with the general level of the plateau, and it is rather a remarkable sight, strongly resembling an old quarry. It is a perfect circle and about 150–200 yards across at the rim. The sides are steep, descending for at least 50 ft. There is deep water at the bottom in which a few penguins were swimming; the water was not icy cold. On its west side the crater cuts through horizontally stratified, light-coloured beds of volcanic ash at least 30 ft. in thickness. On the eastern rim of the crater there is much glassy lava, obsidian, of various hues.

All specimens of the lavas collected from the volcanic cone of Penguin Island represent textural variants of a typical olivine-basalt. The most fully crystallized type comes from the plug in the summit crater. In thin section it is found to be highly porphyritic with numerous phenocrysts of fresh olivine and pale brown augite, sometimes aggregated into clots, and very numerous micro-phenocrysts of plagioclase ($Ab_{55}An_{45}$) with both chemical and mechanical zoning, embedded in an intergranular ground-mass consisting of feldspar microlites mingled with granules of augite and iron ores. In other specimens the ground-mass contains some glassy matter usually blackened with iron-ore dust, and is of intersertal or cryptocrystalline texture.

In one of the rocks olivine is serpentinized and much reduced in amount, but its place is taken by a small quantity of pleochroic hypersthene, illustrating the affinities of these olivine-basalts with the more common hypersthene-augite-andesite lava-type. This association suggests that the olivine-basalts are possibly due to some accumulative process operating in the early stages of the crystallization of a pyroxene-andesite magma from which olivine began to separate.

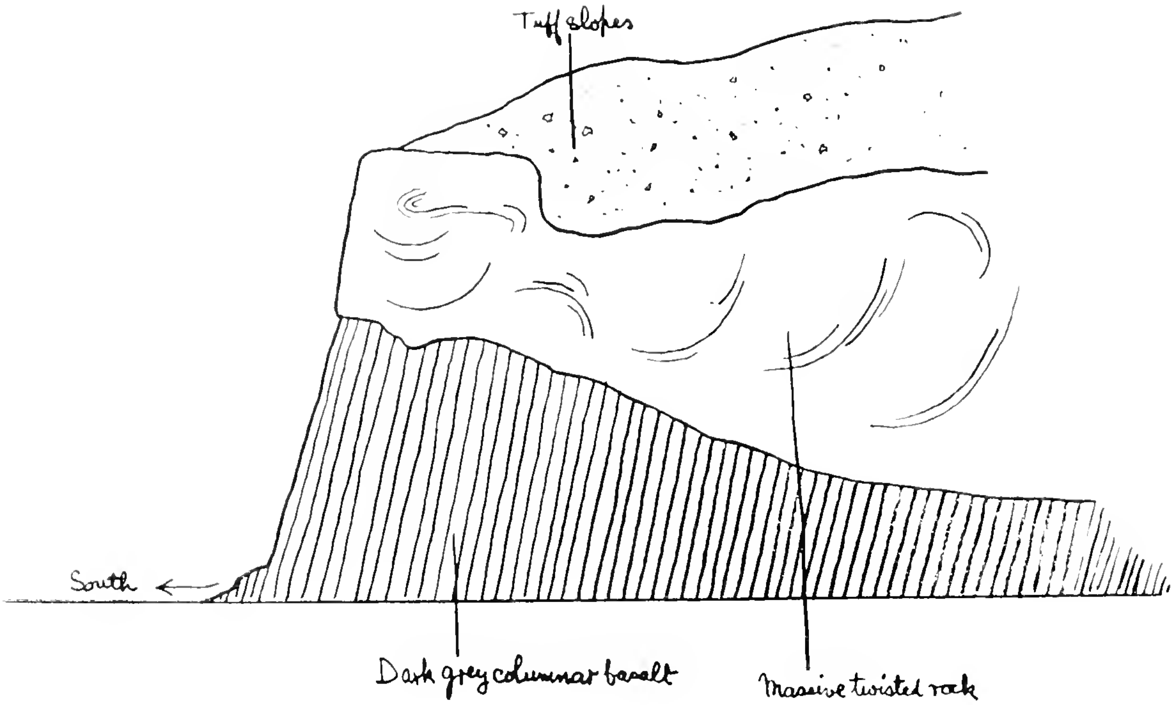
A closely comparable olivine-basalt has been described from Edinburgh Hill, a volcanic vent in Livingston Island on the McFarlane Strait coast (Ferguson, *op. cit.* p. 44; (1), p. 66). Mr Ferguson's fine photograph (*op. cit.* pl. i, fig. 1) illustrates the magnificent columnar structure of this plug. An olivine-basalt also occurs in the Desolation Islands, off the northern coast of Livingston Island (this paper, p. 51). Olivine-basalts of very similar characters have been described by H. H. Thomas from Roberts Island ((2), p. 86). Basalts have also been described from the volcanoes of Deception Island and Bridgeman Island.

The mainland coast opposite Penguin Island, according to Mr Marr, consists of cliffs of lava, fronted by extensive raised shingle beaches. Only one specimen was collected from this locality. This is a typical augite-andesite with a beautiful pilotaxitic texture. The few phenocrysts are small and consist mainly of a colourless augite which is, however, occasionally zoned with cores and bands of a yellowish variety. The remaining phenocrysts are of andesine feldspar (Ab_5An_4). This lava is quite fresh and no doubt belongs to the younger lava series.

Many specimens of the coarse rounded shingle on the beaches of Penguin Island and the adjacent mainland were collected. These consist of the older andesite lavas, together with many of the typical plutonic rocks of the region—granite, adamellite, tonalite, quartz-monzonite, quartz-pyroxene-diorite, etc., and two highly metamorphic types, quartz-chlorite-biotite-schist and hornblende-granite-gneiss.

Martin's Head and The Lion's Rump. These are conspicuous adjacent headlands on the western side of King George Bay. Mr Marr's report states that the basal portion of both headlands consists of a dark grey columnar 'basalt' about 100 ft. in thickness, and with the columns inclined at a steep angle towards the south. At Martin's Head the 'basalt' is overlain by a massive rock with a 'twisted appearance' (? confused columns), and from 50 to 60 ft. in thickness. This in its turn is covered by what appeared to be a tuff (Fig. 3). Behind the headlands are tuff slopes characterized by an abundance of angular rock fragments of many different kinds (? agglomerate). About 200 ft. above the Lion's Rump there is what appears to be an old volcanic crater, now almost completely filled with dirty stagnant ice (Fig. 4). A little to the north of the headland is a conspicuous lava flow reaching the sea. Near by, perched on the beach, are several gigantic erratics of conglomerate, one of which must weigh more than 200 tons. The conglomerate is exceedingly coarse, containing rounded water-worn stones from a few inches in diameter to some 2 ft. across.

The columnar lava of Martin's Head is a fresh hypersthene-augite-andesite of the type common among the younger lava series. An andesite of similar type, but much richer in feldspar phenocrysts, poorer in augite, and apparently devoid of hypersthene, was collected 1 mile east of the Lion's Rump. From the same locality comes a green mudstone, consisting of finely divided quartz and vermicular chlorite, much of the latter being aggregated into small rounded or ellipsoidal pellets. It is difficult to diagnose this rock in the absence of data regarding its field occurrence, but it may be a muddy sediment made up of decomposed wash from a surface composed of the older andesite lavas.



Diagrammatic sketch of Martin's Head.

Fig. 3. Martin's Head.

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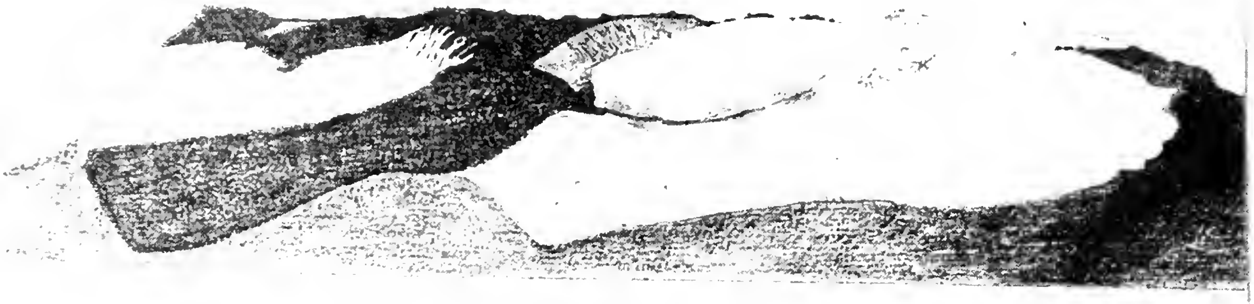

Appearance of old volcanic crater almost completely filled
by very dirty and stagnant ice
Near Martin's Head. King George Island
8.1.37

Appearance of old volcanic crater near Martin's Head

Fig. 4.

The 'conspicuous lava flow' north of the Headland is a doleritic type of andesite characterized by an exceedingly coarse intergranular texture. The rock is mainly composed of laths of plagioclase (Ab_1An_1), pale brown augite, and serpentinous patches which may represent vanished olivine or hypersthene or both. The ferromagnesian minerals form clots as is common in this lava series. A sparingly developed earlier generation of feldspars, slightly larger than the laths, is highly zonal, both chemically and mechanically, and gives rhomboidal cross-sections.

Four specimens of the boulders in the great conglomerate erratics consist of typical augite-andesites differing among themselves only in the texture of their ground-masses. The numerous large phenocrysts consist of plagioclase (mainly about Ab_2An_3), and pale brown augite. Many of the feldspars show strong chemical and mechanical zoning. They are often full of inclusions except for a narrow zone of oligoclase on the margins. Nevertheless, many of the feldspars are quite free from inclusions. In fact the cloudy feldspars look rather like xenocrysts, especially when they occur in juxtaposition to perfectly clear crystals. The facts that these rocks carry the bluish apatites, and occur in a hard coarse conglomerate of well-rounded boulders indicating a long period of erosion, suggest that, notwithstanding their freshness, they belong to the older series of lavas.

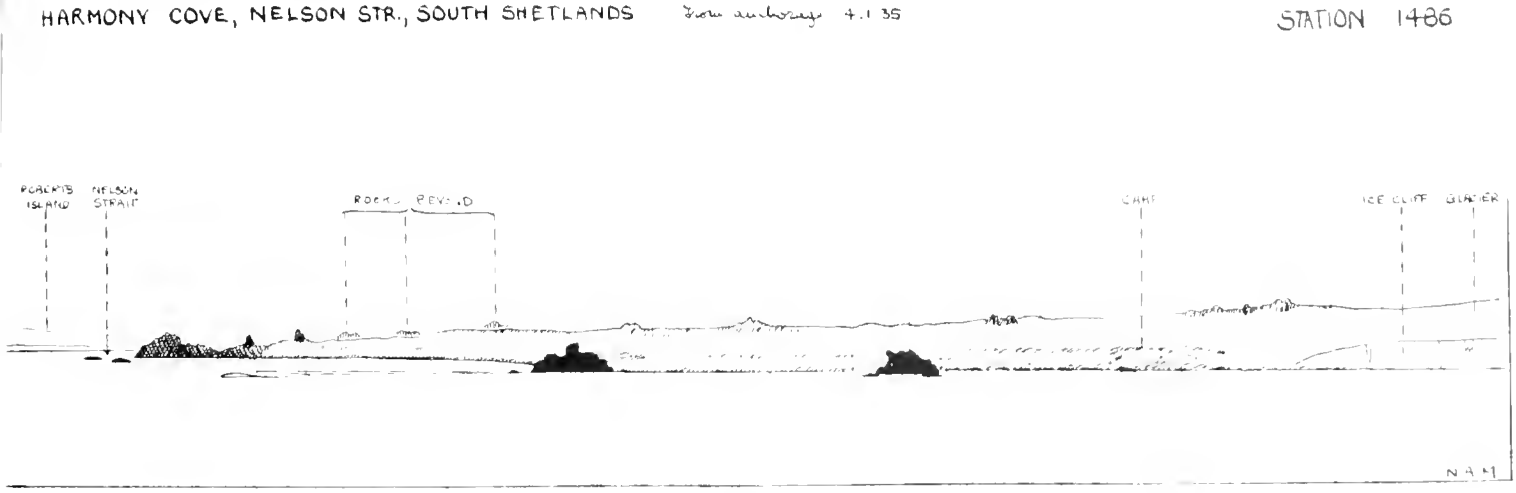

Fig. 5.

Examination of a series of pebbles from the agglomerate in the vicinity of Martin's Head and Lion's Rump shows that the majority consist of hornblende-augite-andesite lavas and their tuffs. In addition, there is an altered doleritic andesite somewhat similar to that described above, a highly epidotized andesite obviously belonging to the older lava series, and an altered tonalite in which the feldspars have been thoroughly sericitized and epidotized, and the ferromagnesian minerals chloritized.

The hornblende-andesite is an unusual type which has not hitherto been described from West Antarctica. In the best-preserved specimen brownish green pleochroic hornblende in well-shaped crystals comes next to plagioclase in abundance as phenocrysts, and is greatly preponderant over augite. The ground-mass is dense and cryptocrystalline.

NELSON ISLAND

Harmony Cove. Very little is known about the geology of Nelson Island. Mr Ferguson (*op. cit.* p. 43) visited Harmony Cove, a harbour at the western corner of the island where Nelson Strait joins Bransfield Strait, and collected a quartz-diorite-porphyry which appeared to be intrusive into an igneous breccia. Dr Mackintosh collected four specimens from Harmony Cove. His account is almost entirely topographical, but he has provided an excellent sketch of the rock exposures (Fig. 5).

Study of these specimens confirms Mr Ferguson's results. One of them is a fine-grained norite consisting of labradorite (somewhat albitized and epidotized), fresh pale augite with which the feldspar laths are sometimes in ophitic relation, numerous brown pleochroic pseudomorphs after hypersthene, and much diffused chloritic matter. There is also a micro-granular variant of this type with porphyritic feldspars and hypersthene (bastite), and highly epidotized. An outcrop near the glacier (Fig. 5) consists of pyroxene-andesite of a type common among the older lava series. It shows porphyritic feldspars (andesine), pale brown augite, and chlorite pseudomorphs after orthorhombic pyroxenes, in a very fine-grained intergranular ground-mass. The fourth specimen, from the shore, is an igneous breccia mainly composed of angular fragments of altered andesite, much epidotized, and peppered with cubes of secondary pyrites. Mr Ferguson's specimen of igneous breccia from the same locality, however, is rich in fragments of the more acid dacitic and rhyolitic lavas.

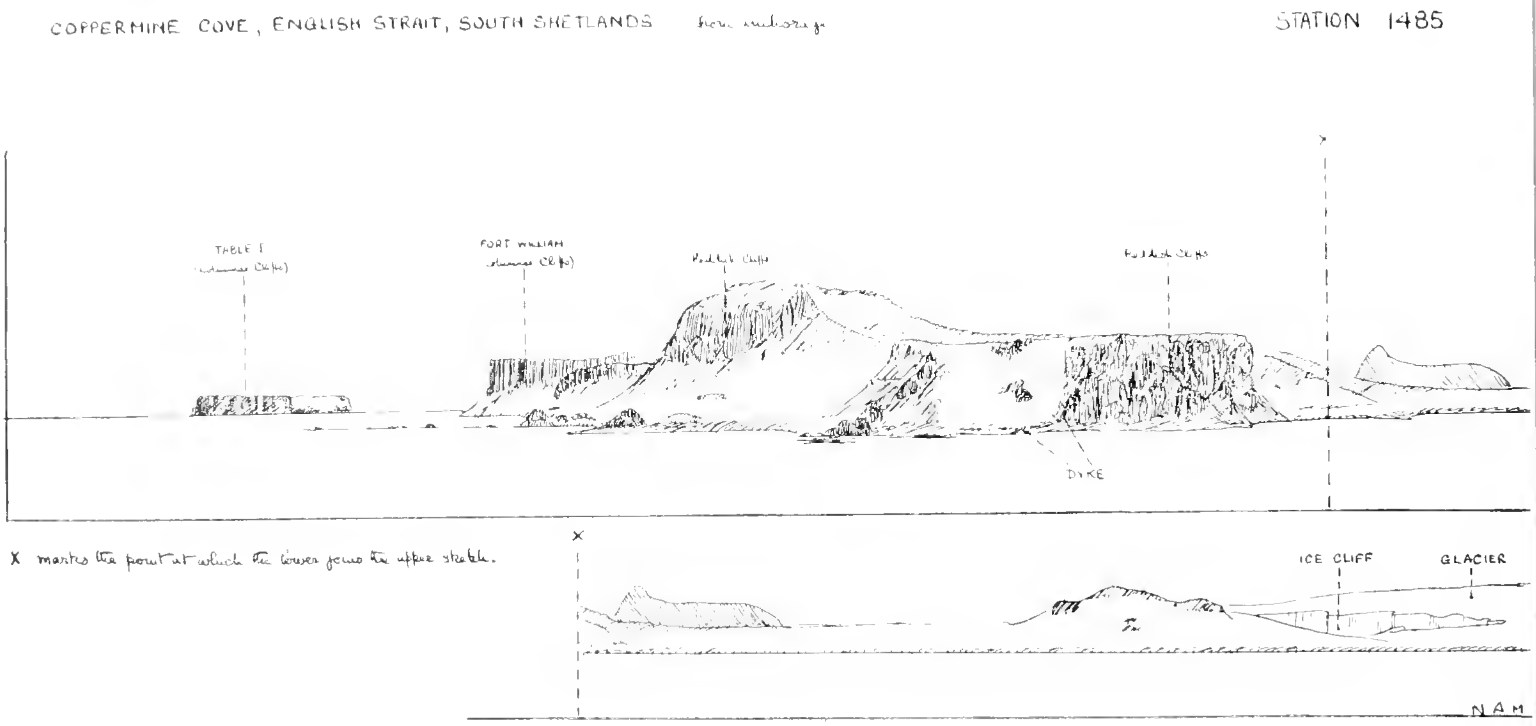

Fig. 6.

ROBERTS ISLAND

Coppermine Cove. This anchorage is situated at the north-western end of Roberts Island, close to the multitude of small islands and rocks which are scattered over the northern exit of English Strait. Specimens were collected by Dr Mackintosh from a small peninsula ending in a flat-topped columnar rock known as Fort William (Fig. 6). Opposite the anchorage (reports Dr Mackintosh) are cliffs of reddish breccia, presumably volcanic, and Fort William appears to consist of columnar basalt. In this respect it resembles Table Island, and many, if not all, of the islets and rocks in the vicinity. Many rock specimens were collected between the anchorage and Fort William. A dike about 5 ft. thick cuts the cliff opposite the anchorage.

The only previous description of rocks from Roberts Island is that by H. H. Thomas ((2), pp. 85–7). He describes five specimens from Coppermine Cove, all porphyritic olivine-basalts and all showing considerable variations in the relative abundance of the porphyritic constituents, and in the richness of the ground-mass in ferromagnesian minerals. Most of Dr Mackintosh's specimens are also olivine-basalts of varying composition and texture. Thus the columnar rock of Fort William is a feldspathic olivine-basalt, or rather dolerite, with a ground-mass of excessively coarse intergranular texture composed of lathy plagioclase (about Ab$_1$An$_1$), pale brown augite, and iron ores. Both feldspar and augite occasionally attain micro-porphyritic dimensions. The abundant fresh olivine, however, forms large phenocrysts.

A 'common type' along the shore is a basalt with numerous small feldspar phenocrysts, and less numerous olivine and augite crystals, embedded in a ground-mass of intersertal texture. This recalls the Dunsapie type of the Scottish Carboniferous, as was also remarked by Dr Thomas. Another type which appears to be abundant in this locality is one with an intergranular ground-mass exceedingly rich in augite. Dr Thomas described rocks of this type but, unlike our specimen, his material contained much olivine. Some of these augite-basalts, as they might be called, carry numerous little prisms of low double refraction and straight extinction which are identified as enstatite, in the ground-mass along with the monoclinic pyroxene. This is an enstatite-basalt. Dr Thomas described a similar rock as hypersthene-basalt.

While most of the specimens collected here are basalts, one is an augite-andesite of the common type belonging to the younger lava series. It is accompanied by an andesitic agglomerate. Beach pebbles collected from Coppermine Cove consist of tonalite and granite-aplite.

LIVINGSTON ISLAND

Livingston Island is the second largest of the South Shetland group, but very little is known of its geology. Mr Ferguson collected an olivine-basalt from a fine columnar exposure forming a small island off the coast in McFarlane Strait (Edinburgh Hill), and noted tuffs in the vicinity which, beside basalt, contained fragments of quartz-diorite and black mudstone (*op. cit.* p. 43 and pl. i, fig. 1).

Desolation Island. Dr Mackintosh collected a few specimens from Desolation Island which lies off the northern coast of Livingston Island. He gives no geological details except that the island is mainly composed of a columnar igneous rock. It is noteworthy that on the Discovery Chart (*Discovery Reports*, vol. VI, 1932, Chart 6) Desolation Island is represented in the shape of an irregular broken ring, suggesting that it may be a breached crater flooded by the sea; but this resemblance may, of course, be quite accidental.

Two of the specimens were collected *in situ* from columnar outcrops. Both are very fresh and coarse-grained hypersthene-basalts of an unusual type. The major part of both rocks consists of a coarse intergranular admixture of laths of labradorite (An$_{60}$–An$_{70}$) with granules of pale green augite, prisms of enstatite-hypersthene with faint pleochroism, and iron ores. The feldspar and augite occasionally form somewhat larger micro-porphyritic crystals, but the rock is not conspicuously porphyritic. Both kinds of pyroxene, moreover, tend to build small aggregations or clots, which stand out as a glomero-porphyritic texture. Olivine occurs only sparingly as small pseudomorphs in brownish serpentine. A small amount of dark brown glass fills up interstices in the ground-mass.

A basalt with orthorhombic pyroxene in the ground-mass was described by Thomas from Roberts Island ((2), p. 86). Olivine did not occur in this rock, and the augite occasionally formed glomero-porphyritic aggregates. A closely comparable rock from the same locality has been described in this paper (p. 51). These rocks are no doubt closely related to the basic hypersthene-augite-andesites above described, which are so common in the South Shetland Islands. In these rocks, however, the hypersthene is porphyritic and does not occur in the ground-mass. Barth and Holmsen have given an interesting discussion of the petrographical problem involved in the presence of hypersthene in these rocks ((4), pp. 14–17).

Numerous pebbles from the beaches and fragments from the screes of Desolation Island were collected. These include tonalite and a sericitized and chloritized diorite, silicified andesitic breccia, and a series of acidic volcanic rocks including a fluxional rhyolite or dacite with augite, a rhyolitic tuff made up of angular fragments of the fluxional rock, a biotite-rhyolite, and orthoclase-porphyry or felsite with only sparse phenocrystic quartz. Finally, a fragment collected from the scree on the cliffs of a rocky islet near the anchorage turns out to be a crushed sericitic quartzite of a distinctly ancient aspect.

DECEPTION ISLAND

Deception Island is the best known of the South Shetland Islands. Dr Thomas ((2), p. 81) has commented on the earlier literature of the island. Mr Ferguson added a few details and published two excellent photographs (*op. cit.* p. 44; pl. iii, figs. 2, 3); but the fullest recent description is that by Holtedahl ((3), pp. 29–47). Deception Island apparently represents a huge breached crater flooded by the sea, of which the inner diameter is about 8 km. Holtedahl believes, however, that it is not a single large crater, but a volcanic ring mountain built around a caldera subsidence bounded by a circular fault or series of faults.

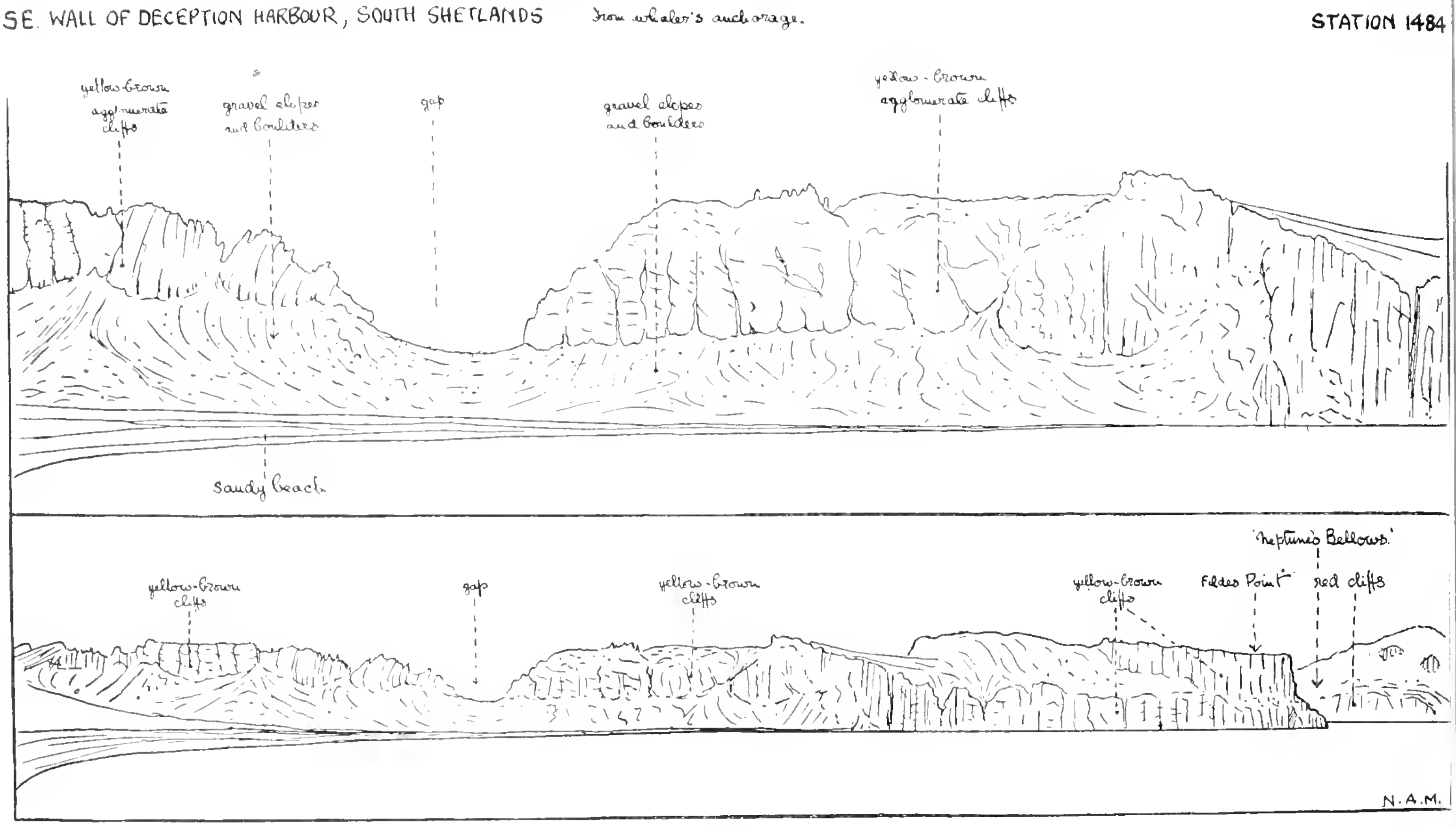

Fig. 7.

Dr Mackintosh collected material from the cliffs and slopes on the south-east side of the whaler's anchorage near the entrance to Deception Harbour. These form a narrow ridge of land separating the anchorage from Bransfield Strait (see Dr Mackintosh's sketches, Fig. 7). He reports that the whole of the cliffs shown in the sketch, except beyond Neptune's Bellows,[1] consist of an 'agglomerate of ashes in a yellowish matrix'. It is possible that the yellow colour is mainly superficial, as freshly broken surfaces generally seem darker. The slopes below the cliffs are mainly of a soft gravel obviously formed from the disintegrated agglomerate, carrying a fair proportion of solid boulders of agglomerate, and here and there boulders of a harder dark rock presumably derived from intrusions in the agglomerate (andesitic basalt).

[1] Apparently the name given to the entrance channel of Deception Harbour.

A visit was also made to the bluff on the south-west side of Neptune's Bellows (Fig. 7). The lower part consists of conspicuous red cliffs, but higher up there are outcrops of the yellowish agglomerate characteristic of the other side of the channel. The main range of hills in this locality appeared to be composed of 'cindery lava or scoria' with reddish black tints. It appears to be the weathered surfaces of this rock which impart the striking red colour to the lower cliffs. Three rock specimens were collected from this locality, and a few from localities north of Whaler's Bay (Anchorage?).

The petrography of Deception Island has been dealt with by the writer ((1), pp. 67, 71), who described olivine-basalt and basaltic tuffs,[1] and hyalo-dacite (ungaite). Dr H. H. Thomas ((2), pp. 81–5) described ophitic olivine-dolerite, various types of andesite and their tuffs (mostly glassy), and soda-trachyte (oligoclase-trachyte). He also noted the presence of tridymite and iron-olivine (fayalite) in some of the more acid types, and of anorthite in the hyalo-andesites. Barth and Holmsen ((4), pp. 8–17) described andesine-basalt and a vesicular, glassy 'pillow-lava', both of which they regarded as of bandaitic composition, a view which is borne out by their chemical analyses. Furthermore, they gave a full description of a rock which seems to be identical with my oligoclase-dacite and Thomas's oligoclase-trachyte. Barth and Holmsen find the closest analogues of this rock in the products of the Santorin volcano in the Aegean Sea, and as it contains 17 per cent of tridymite they call it tridymite-santorinite.

From the study of Mr Ferguson's original specimens on which I based my first account of the rocks of Deception Island, of Dr Mackintosh's new material, and of the above literature, it seems clear that four main types of rock have been erupted from the Deception Island volcano, namely, olivine-basalts or dolerites (of which there are no analyses), lavas of bandaitic composition, hyalo-andesites of more acid type, and finally, the trachytic type which has been variously called oligoclase-dacite, oligoclase-trachyte, and tridymite-santorinite. Eight analyses of Deception Island rocks have been published (p. 58) from which it seems clear that they form a perfectly gradual series varying from basic to acid, all of which (except the olivine-basalts) are highly sodic and relatively poor in potash; and are mineralogically characterized by the presence of calcic feldspars, orthorhombic and monoclinic pyroxenes, and, in the more acid types, by fayalite, tridymite, and sodic feldspars.

The following account of the petrography of Deception Island is based on the study of the specimens collected by Dr Mackintosh, and on the re-study of the material collected by Mr Ferguson ((1), pp. 58 *et seq.*).

Olivine-basalt. Only two rocks, both from the Ferguson collection, belong to this type. One is described in the following terms ((1), p. 67): 'A beautifully fresh rock showing more or less rounded olivine phenocrysts in a ground-mass of good fluidal texture, which consists of elongated microlites of labradorite with subordinate granules of augite and magnetite.' The texture can be described more exactly as fluxional intergranular. A few of the augite crystals are of slightly larger dimensions and more euhedral than the granules of the ground-mass, and can be regarded as micro-phenocrysts. The rock has a close resemblance to the Dalmeny type of the Scottish Carboniferous basalts. Its occurrence is as a pebble in a tuff or agglomerate.

The other olivine-basalt is flow-banded in the hand specimen, but its ground-mass is not so conspicuously fluxional as the above. The ground-mass is of coarse intergranular type and consists of laths of andesine, with granules of pale augite and magnetite. Numerous phenocrysts and glomeroporphyritic aggregates of fresh olivine and brown augite, together with smaller and much less numerous feldspar crystals (labradorite) are embedded in the ground-mass. This rock has affinities with the Craiglockhart and Dunsapie types of the Scottish Carboniferous basalts.

Basaltic andesites of bandaitic type. These rocks differ from the basalts described above in not

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[1] These are now regarded as andesitic tuffs.

being conspicuously porphyritic, and in being almost or quite devoid of olivine. All but one of the six specimens available come from Dr Mackintosh's collection, and were obtained from both sides of the entrance channel to Deception Harbour. The ground-mass is of the same type as that of the basalts, that is, composed of andesine laths, and granules of augite and iron ores. A plagioclase of somewhat more basic character forms numerous laths which run in wavy flow-lines through the ground-mass. A few large phenocrysts of augite may occur, but olivine, if present at all, is always in very small quantity, and is altered to brownish serpentine. The ground-mass varies in texture from coarsely intergranular to fine-grained intersertal, with a brownish glassy base blackened with iron-ore dust.

These rocks are adjudged to be the same as those described by Barth and Holmsen ((4), p. 9) as andesine-basalt and pillow-lava of bandaitic type, of which they have provided chemical analyses (p. 58). Dr Thomas, too, described what is apparently the same type, in the more basic varieties of his 'hyaloandesites' ((2), p. 82). Both Barth and Holmsen, and Dr Thomas, mention hypersthene as a constituent of this rock type, but the writer was unable to identify orthorhombic pyroxene with certainty in the material at his disposal.

Andesite (*hyalo-andesite*). This is the most abundant rock type in both Mr Ferguson's and Dr Mackintosh's collections. As the analyses show (p. 58), there is a continuous series of compositional types from the basic bandaites to the relatively acid oligoclase-andesites (santorinites), varying chiefly in silica percentage and proportion of ferromagnesian to feldspathic minerals and quartz. As many of the rocks are of glassy facies, these variations are masked, at least mineralogically, by the glassy matrix; in thin section the rocks present a relatively unvarying appearance and, except for one or two more crystalline types, may be grouped as hyalo-andesites. Dr Thomas ((2), p. 82) described several rocks from Deception Island under this heading.

In hand specimens these rocks are black or dark grey in colour, usually slaggy, vesicular or even pumiceous, and are obviously of glassy nature. Even the more crystalline varieties are black and of dense texture. From these black slaggy types there are all transitions to dark, non-vesicular, glassy rocks, resembling pitchstones, which are, however, more acid than the majority of the types grouped under the name hyalo-andesite, and properly belong to the oligoclase-andesites or santorinites.

In thin section many of these slaggy rocks are found to be composed of a brownish glass, dusted thickly with black specks of iron ores, and often highly vesicular. They always show swarms of plagioclase microlites (oligoclase to andesine), usually in parallel fluxional streams, but occasionally felted together with the production of pilotaxitic texture. Microlites of pyroxene can often be detected in varying numbers by their bright polarization tints and oblique extinction. Some microlites, however, which are indistinguishable from the pyroxenes in their appearance under ordinary light, have a very high double refraction and straight extinction.[1] It is probable, therefore, that these are olivines. Olivine does actually occur in very small amount in a few of the rocks as micro-phenocrysts, and is almost invariably altered with the production of a reddish serpentine. There are also occasional micro-phenocrysts of andesine and augite.

From these highly vitreous types there are all gradations to almost holocrystalline (micro-crystalline) types consisting of a very dense intergranular admixture of plagioclase microlites with granules of augite and iron ore, which carries fluxional streams of plagioclase laths.

Dr Thomas detected well-formed crystals of tridymite lining steam cavities and planes of flow in these rocks ((2), p. 84). Barth and Holmsen ((4), p. 11 *et seq.*) found no less than 17 per cent of tridymite lining steam cavities in one of the more acid types. The writer found abundant tridymite in only one of the vesicular hyalo-andesites. It lines and fills steam cavities and fracture cracks in

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[1] Barth and Holmsen ((4), p. 9) have also noted small elongated crystals of olivine in the ground-mass of these rocks.

the rock. Associated with and apparently passing into the tridymite aggregates there are a number of small spherulites giving a perfect extinction cross, of which the constituent fibres have straight extinction and a refractive index much lower than that of canada balsam. While these may be tridymite, it is possible that they represent cristobalite. A. G. MacGregor has described both tridymite and cristobalite from the Recent lavas (pyroxene-bandaite) of Montserrat.[1] He writes: 'The cristobalite, besides obviously replacing tridymite laths and twins, often occurs as innumerable rounded to irregularly shaped spots up to 0·1 mm. across', but he does not mention any spherulitic structure.

Oligoclase-andesite (oligoclase-trachyte—Thomas; santorinite—Barth and Holmsen; oligoclase-dacite (ungaite)—Tyrrell). This rock represents a somewhat more acid development of the magma which gave rise to the hyalo-andesites above described. Its nomenclature presents a rather perplexing problem, and it has been given various names by different authors as shown above. As indicated by the analyses (p. 58), the free silica works out at between 15 and 20 per cent. The writer has shown that the average andesite contains round about 15 per cent of normative quartz;[2] and as the principal feldspar in the rocks under discussion is oligoclase, it is thought that *oligoclase-andesite* is the best name for the type. It is, however, of somewhat unusual composition, as shown by Barth and Holmsen ((4), p. 13), in that the ratio of soda to potash is much higher than in normal andesites. They have marked this distinction by conferring the name *santorinite*, since the lavas of Santorin are found to be the closest analogues of this rock type. Perhaps the most acid types should be called *oligoclase-dacite* to mark the presence of as much as 20 per cent of free silica.

In hand specimens these rocks vary from light grey compact 'stony' to black pitchstone-like material, which carries scattered whitish crystals of feldspars and often shows marked parallel banding due to flow.

In thin section they are seen to contain very sharply bounded micro-phenocrysts of plagioclase, augite, enstatite, olivine (fayalite) and magnetite, embedded in a ground-mass which varies greatly in its proportion of glass to crystals. The glass may form at least 50 per cent of the ground-mass; at the other extreme the rocks may be almost completely crystalline. The glass is usually yellowish brown in colour, but may be colourless; it contains many minute needle-like crystallites. Numerous microlites of oligoclase-albite (and perhaps a potash-soda feldspar) stream through the glass in fluidal fashion, mingled with minute granules of pyroxenes and iron ores. The feldspar micro-phenocrysts were identified in my earlier memoir as anorthite ((1), p. 71). Dr Thomas also found anorthite in his material ((2), p. 82), but Barth and Holmsen ((4), p. 11) apparently noted only andesine of composition $Ab_{65}An_{35}$. The ferromagnesian phenocrysts include augite (probably diopside) in well-shaped prisms and octagonal basal sections, enstatite and fayalite. The micro-phenocrysts often cluster in groups. Only one of the rocks was vesicular, and in it was found tridymite lining steam cavities exactly as reported by Barth and Holmsen.

These rocks resemble some of the more basic pitchstones of the Tertiary igneous episode in the west of Scotland, notably the types called *leidleite* and *inninmorite*,[3] especially the latter, which is reported to contain anorthite phenocrysts. Indeed, the text-figures of the microscopic appearance of leidleite and inninmorite (e.g. figs. 47, 48) given in the Mull *Memoir* cited above might pass for some of the hyalo-andesites and oligoclase-andesites of Deception Island.

Tuff and agglomerate. Every account of Deception Island emphasizes the abundance of fragmental volcanic rocks—tuff and agglomerate—in the constitution of the volcano. Five specimens from

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[1] The Royal Society Expedition to Montserrat, B.W.I.: 'The Volcanic History and Petrology of Montserrat, with Observations on Mont Pelé, in Martinique', *Philos. Trans.*, B, CCXXIX, 1938, pp. 58–61.

[2] G. W. Tyrrell, 'Some Tertiary Dykes of the Clyde Area', *Geol. Mag.* 1917, p. 311.

[3] 'Tertiary and Post-Tertiary Geology of Mull, Loch Aline and Oban', *Mem. Geol. Surv. Scotland*, 1924, pp. 281–4.

Dr Mackintosh's collection have been sliced, and they are found to be singularly uniform in composition. They are made up of irregular, angular, and highly vesicular lapilli and scoria, the fragments usually varying in size between a hazel-nut and a walnut. The fragments consist of glassy forms of both the basic and acid andesitic types, the black opaque slaggy form and the clear glassy form being about equally abundant. The glassy fragments are frequently of a bright yellow colour, but some are brown and a few others of a greenish tint. Many of these fragments have a narrow border of the black opaque variety, suggesting that the separation of magnetite dust in the glass which gives rise to the opacity may be due to a reheating or annealing process. There is little or no matrix of finer material between the fragments, and they appear to be welded together along their contacts. This material therefore might be better classed as *agglutinate*[1] than as agglomerate.

Tridymite (and cristobalite?) occurs abundantly in these fragmental rocks, not only lining the vesicles of the glassy fragments, but also as an edging around the individual fragments. This suggests that, in these rocks at any rate, the tridymite is of deuteric crystallization. It has been formed shortly after the consolidation of the fragmental material, and is no doubt due to late emanations derived from the parent magma.

SNOW ISLAND

This is a small island west of Livingston Island, and west-north-west of Deception Island. It is geologically unknown, and no description and no record of any landing is known to me. Four specimens of rocks from Snow Island, however, were found in the first set of material sent to me by the Discovery Committee, with no record when and by whom collected. Three of the rocks appear to have been collected *in situ* from actual exposures, but the fourth is a pebble from a raised beach at 50 ft. above present sea-level on the eastern coast of the island.

Of the three specimens collected *in situ* on the eastern side of the island one is a quartz-pyroxene-diorite or feldspathic quartz-gabbro of a type identical with other occurrences in the South Shetland Islands and the Palmer Archipelago; the second is an oligoclase-andesite breccia with a tuffaceous matrix containing a good deal of quartz. The third is a quartz-felsite or rhyolite with a scanty cryptocrystalline matrix. The pebble from the raised beach is quartz-augite-microdiorite, identical with the quartz-pyroxene-diorite above mentioned except that it contains patches of fine-grained ground-mass.

Even from this scanty material, therefore, the indications are clear that the constitution of Snow Island is the same as that of the other islands of the South Shetlands group, and that rocks of the older igneous series are here represented.

DREDGINGS FROM BRANSFIELD STRAIT

A few score of stones dredged from two stations in Bransfield Strait were included in the first collection of rocks received from the Discovery Committee. These came from St. 175, about 25 miles south-east of Deception Island, and St. 177, about 27 miles south-west of Deception Island, and were dredged from depths of 200 and 1080 m. respectively. The stones were probably dropped from the ice which formerly occupied Bransfield Strait, and which probably moved from the west and south-west. Some of the material may have been carried by icebergs breaking away from glaciers on the South Shetlands and the Graham Land coast. The specimens range in size from blocks 6 in. across to $\frac{1}{2}$ in. pebbles. Most of them are angular and facetted, with corners and edges roughly rounded off; only a few appeared to be well-rounded, apparently water-worn pebbles.

As was to be expected, the great majority of the seventy-nine stones sliced consist of the older series of andesites, dacites, rhyolites, agglomerates and volcanic breccias, which appear to constitute

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[1] G. W. Tyrrell, *Volcanoes* (Home University Library), 1931, p. 66.

the main part of the South Shetlands, and perhaps some part of the Palmer Archipelago and the Graham Land coast. There is also one hyalo-andesite with good tridymite which certainly comes from Deception Island and two others which probably come from the same source. Rocks of plutonic aspect are also well represented in this collection. They include the quartz-pyroxene-diorites and their porphyries which are common in the South Shetlands and adjacent regions. Diorite, tonalite, granodiorite, biotite-granite, and their porphyries, together with granophyric granites and true granophyres, which more probably come from the Palmer Archipelago and adjacent parts of Graham Land, are also fairly abundant. Rarer types are represented by a basic diorite with abundant brown hornblende, biotite, and apatite; and a serpentine derived from augite-peridotite.

The most interesting material, however, is provided by specimens of sedimentary and metamorphic character, which are unrepresented among the rocks in the Discovery collections obtained from actual exposures. Little is known of these rock types in the South Shetlands and adjacent regions as they have attracted little attention, perhaps owing to the relatively great abundance and conspicuous characters of the igneous rocks.

Many of the sediments represented among the dredged stones have suffered a low-grade cataclastic metamorphism by crushing and shearing. Among the unaltered sediments are mudstone, siltstone, greywacke, arkose and sandstone. There are two mudstones, and both appear to represent exceedingly fine-grained washes from the weathered surfaces of basic lavas. Microlites of plagioclase can be recognized in a chloritic and ferruginous clay matrix, and in one of them there is a sparse sprinkling of angular quartz grains of silt grade. Another mudstone of similar type has undergone a little crumpling and shearing with the development of thin quartz-chlorite veins.

Seven pebbles appear to represent laminated sediments consisting of alternate beds of greywacke and siltstone or slate in various stages of shearing and crushing. The least altered specimen shows angular grains of quartz and subordinate feldspar in a siliceous ground-mass of silt grade in which quartz is mingled with finely divided sericite, chlorite, epidote and iron ores. This material is penetrated by thin veins of secondary silica, now recrystallized to lines of granular quartz. The other members of this series have undergone severe cataclasis, whereby ultimately quartz-chlorite-schist has been developed from the greywacke bands and phyllite from the slaty bands. Three of the specimens show signs of having first been broken up by crushing into an angular breccia in which, by further shearing, the fragments have been drawn out with the production of a kind of mortar structure, and with the development of much coarse chlorite and white mica. In one specimen, which is relatively poor in quartz and rich in chlorite and epidote, it is probable that basic igneous rock fragments made up the greater part of the original greywacke. The extreme term of alteration is represented by a true schist consisting largely of quartz, biotite and sericite, in which mortar structure is finely developed.

One specimen is an interesting arkose consisting of extremely angular grains of quartz, alkali-feldspar and plagioclase, small chips of andesite and keratophyre (?), a few bits of garnet and epidote, and many flakes of unaltered biotite, in a ferruginous clay matrix. This composition suggests the rapid waste of a mixed terrain consisting of granitic rocks, andesitic lavas, and perhaps some metamorphic rocks.

Finally, there is a true sandstone consisting mainly of angular to subrounded grains of quartz, with less abundant grains of alkali-feldspar and plagioclase, a few chips of slate and siltstone and, above all, many large angular fragments of pale garnet.

Mudstones, greywackes, quartzites and igneous breccias have been described from the South Shetlands, but especially from the Palmer Archipelago ((1), p. 74; (4), p. 28). Ferguson (*op. cit.*, p. 37) described siliceous and argillaceous sediments interbedded with the lavas and tuffs of the older igneous series in Admiralty Bay, King George Island. The present study of dredged stones from Bransfield Strait has brought out the fact that somewhere in the surrounding region there must be a basement series of greywackes, mudstones and slates, which has undergone severe cataclastic metamorphism. There is good evidence from contact-metamorphic effects that the plutonic masses of the South Shetlands, the Palmer Archipelago and Graham Land, have broken through this sedimentary basement ((1), pp. 75–7), and also through the older series of andesite lavas. Hence the metamorphosed sedimentary basement must be at least of early Mesozoic age, and quite possibly Palaeozoic.

CHEMICAL CHARACTERS

For a discussion of the chemistry of the igneous series of the South Shetland Islands there are available twelve previously published analyses and two others made for the present investigation and here published for the first time. Seven of the twelve published analyses were given by E. Gourdon

Table 1*a*. *Analyses of igneous rocks from Deception Island*

	1	2	3	A	4	5	6	7	8
SiO_2	69·01	68·28	67·71	68·33	60·62	56·89	52·93	53·50	49·84
Al_2O_3	14·21	15·95	14·65	14·94	16·22	16·07	15·86	17·62	19·37
Fe_2O_3	2·23	2·00	1·59	1·94	1·76	1·81	2·01	2·58	3·42
FeO	2·89	1·82	3·29	2·67	5·67	7·08	8·90	6·07	3·69
MgO	0·62	0·09	0·85	0·52	1·62	2·79	3·63	4·39	4·71
CaO	2·11	1·78	2·34	2·08	4·18	5·89	7·60	9·22	12·35
Na_2O	6·30	7·03	6·09	6·47	6·25	5·89	5·03	4·15	2·50
K_2O	2·07	1·75	1·99	1·94	1·20	0·94	0·64	0·75	0·87
H_2O	0·09	0·24	0·16	0·16	0·56	0·56	0·42	0·00	1·79
H_2O						0·08	0·04		
TiO_2	0·58	0·70	1·00	0·76	1·54	1·79	2·29	1·65	1·32
P_2O_5	0·12	0·07	0·16	0·12	0·24	0·21	0·35	0·36	0·11
MnO	—	—		—	—	0·08	0·11	—	—
S	—	—		—	—	0·06	0·06	—	—
	100·23	99·71	99·83	99·93	99·86	100·14	99·87	100·29	99·97
Q	21·1	18·5	20·1	20·2	8·1	1·9	− 1·0	2·0	2·7
F′	64·9	70·5	62·5	65·3	60·5	55·2	46·2	39·0	26·7
M′	14·0	11·0	17·4	14·5	31·4	42·9	54·8	59·0	70·6
nak	89·2	84·1	82·6	84·9	71·7	66·4	56·4	43·1	26·3
k	17·7	14·3	17·7	16·1	11·4	9·5	8·0	10·1	20·0

1. Trachyandesite, Deception Island. E. Gourdon, *C.R. Acad. Sci., Paris*, CLVIII, 1914, p. 1906.
2. Tridymite-santorinite, Deception Island. Barth and Holmsen ((4), p. 14).
3. Trachyandesite, Deception Island. Gourdon, *op. cit.*

A. Average of nos. 1, 2, and 3.

4. Andesite,* Deception Island. Gourdon, *op. cit.*
5. Bandaite,† pillow-lava, Deception Island. Barth and Holmsen ((4), p. 11).
6. Andesine-basalt, Deception Island. Barth and Holmsen ((4), p. 11).
7. Basalt ('Labradorite'—Gourdon), Deception Island. Gourdon, *op. cit.*
8. Doleritic basalt, block (in tuff or agglomerate?) Deception Island. Gourdon, *op. cit.*

* The alkalis in this analysis are given as recorded in Gourdon's first paper of 1914, i.e. Na_2O, 6·25; K_2O, 1·20. In Washington's Tables (*U.S.G.S. Prof. Paper* 99, 1917, p. 466) the alkalis are given as Na_2O, 6·67; K_2O, 0·78, and as the summation remains the same it seems clear that 0·42 per cent has been transferred from K_2O to Na_2O. This may have been a correction of the original analysis when it was transmitted to Washington by Gourdon, but it has been thought best to leave the original figures intact, especially as they are repeated in Gourdon's later work published in *Deuxième Expédition Antarctique Française* (1908–1910), *commandé par le Dr Charcot*: *Minéralogie, Géologie*, Paris, 1917, p. 7. The earlier figures for the alkalis are also more accordant with the serial characters of the Deception Island suite than the later.

† Correct summation, 100·14, given in the table. Barth and Holmsen give 100·08.

in a short paper, 'Sur la constitution minéralogique des Shetland du Sud' (*sic*),[1] with only exiguous petrographical notes. Four new analyses are given in the 1939 paper of Barth and Holmsen ((4), pp. 11, 14, 25). The remaining analysis is a computation made from a Rosiwal estimate of mineral proportions in a quartz-gabbro from King George Island by the writer ((1), p. 65). The two new analyses made for this work are of a tholeiitic lava type from Fildes Strait (p. 44), and of the Recent olivine-basalt lava of the Penguin Island volcano (p. 45). Thus there are now available analyses of eight rocks from Deception Island, five from King George Island, and one from Bridgeman Island.

Table 1*b*. *Analyses of igneous rocks from King George Island and Bridgeman Island*

	9	10	11	12	13	14
SiO_2	57·30	54·9	53·45	53·02	48·26	54·24
Al_2O_3	17·97	15·6	19·37	15·57	17·42	17·20
Fe_2O_3	2·17	5·4	3·37	4·40	3·36	2·81
FeO	3·79	7·0	4·09	6·58	5·61	4·98
MgO	2·57	2·7	4·42	3·93	8·83	5·84
CaO	6·72	9·1	8·18	8·15	11·56	10·19
Na_2O	3·25	2·9	3·55	2·38	2·44	2·91
K_2O	0·96	1·7	1·35	1·68	0·89	0·92
H_2O^+	4·26		1·69	2·02	0·24	0·09
H_2O				0·50	0·16	
CO_2	—		—	tr.	nil	—
TiO_2	0·56	—	0·66	1·16	1·07	0·91
P_2O_5	0·20	0·7	—	0·35	0·22	0·09
MnO			0·04	0·16	0·14	—
	99·75	100·0	100·17	99·90	100·20	100·18
Q	17·3	10·6	3·8	10·7	−5·2	5·3
F′	34·7	34·7	38·5	30·9	25·0	29·3
M′	48·0	54·7	57·7	58·4	80·2	65·4
nak	35·8	42·5	37·9	37·2	28·6	33·7
k	17·5	27·7	20·8	31·6	18·4	17·5

9. Hypersthene-andesite, Admiralty Bay, King George Island. Gourdon, *op. cit.*
10. Quartz-gabbro, intrusion, Le Poing, Admiralty Bay. Tyrrell ((1), p. 65).
11. 'Dolerite',‡ dike, Admiralty Bay. Barth and Holmsen ((4), p. 25).
12. Tholeiitic basalt, lava, Fildes Strait, King George Island. New analysis by F. Herdsman.
13. Olivine-basalt, lava of Recent volcano, Penguin Island, King George Bay, King George Island. New analysis by F. Herdsman.
14. Basalt, Bridgeman Island. Gourdon, *op. cit.*

‡ The description of this rock by Barth and Holmsen makes it tolerably clear that it is a porphyritic hypersthene-augite-andesite, practically identical with the rock of the dike in Admiralty Bay described in the present paper (p. 43). As this is a very conspicuous feature in Admiralty Bay, it is very probable that the two specimens come from the same dike.

The fourteen available analyses are set out in Tables 1*a* and 1*b* in the above geographical order. The von Wolff normative parameters as modified by the writer are also given.[2] In these *Q* represents the excess or defect of molecular silica, a positive number giving the amount of normative quartz, and a negative figure representing the amount of olivine. *F′* is the percentage amount of normative alkali-feldspar (orthoclase and albite), and *M′* the combined percentage of anorthite, pyroxene,

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[1] *C.R. Acad. Sci., Paris*, CLVIII, 1914, pp. 1905–7.

[2] A full account of this method of calculation will be published as soon as possible.

iron ore and apatite. The symbol *nak* represents the percentage of alkali-feldspar in total feldspar, and *k* the percentage of potash feldspar in total alkali-feldspar. Thus:

$$nak = \frac{\text{salic } (Na_2O.K_2O)}{\text{salic } (Na_2O.K_2O.CaO)} \; 100,$$

$$k = \frac{\text{salic } K_2O}{\text{salic } (Na_2O.K_2O)} \times 100.$$

The geographical arrangement of the analyses in Tables 1*a* and 1*b* shows at once that there is a considerable difference between the Deception Island series at the southern end of the South Shetland archipelago, and that of King George Island and Bridgeman Island at its northern end. The Deception Island series is characterized throughout (except no. 8) by comparative richness in alkalis as against lime, as shown by the high *nak* ratios. Moreover, in the alkalis, soda is extraordinarily high in relation to potash, as is shown by the low *k* ratios. The members of this series show regular chemical variations throughout, again with the exception of no. 8, which stands apart in several particulars. This rock is described by Gourdon as 'doleritic basalt'. It is stated to occur as 'blocks' (? in agglomerate or tuff), and is not found *in situ*.[1] As its analysis agrees fairly closely with those of the Recent basalts of King George Island (no. 13) and Bridgeman Island (no. 14), it is possible that the rock represents a fragment torn from a foundation of Recent basalts through which the Deception Island volcano, of quite different constitution, has burst. It will be so regarded in the present investigation.

The serial relations of the Deception Island series are shown in the variation diagram (Fig. 8). The silica percentages, and the values for *F′* and *M′*, were tried as abscissae against which the other constituents were plotted. It was found that *F′* gave the smoothest curves. In all cases analysis no. 7 (Gourdon's 'labradorite') was somewhat discrepant from the others. The curves show the same general trends as for other andesitic series. The distinguishing feature of the diagram, however, is the height of the Na_2O curve and its distance from the K_2O curve.

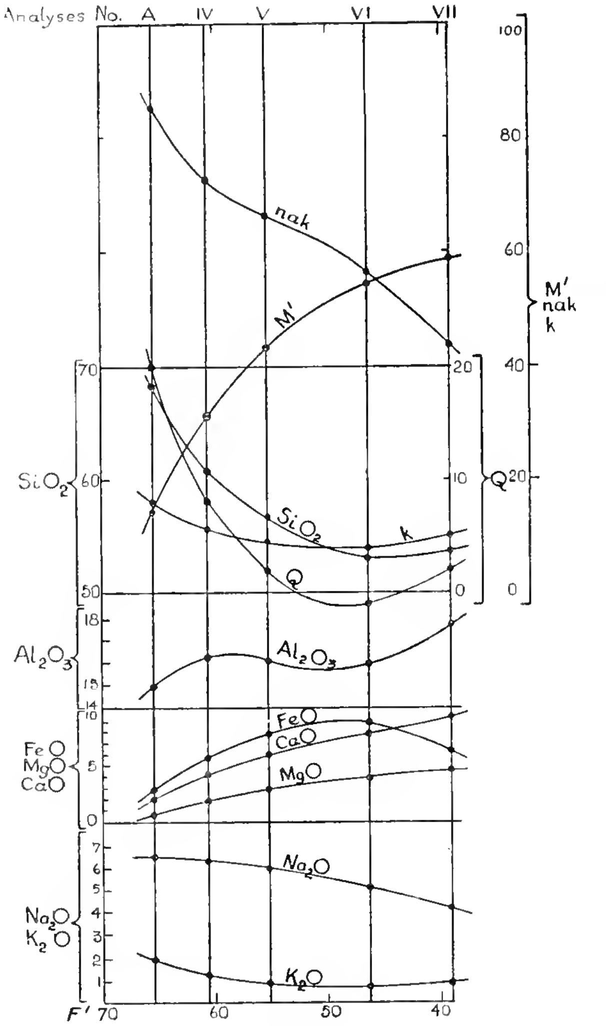

Fig. 8.

The Deception Island rocks may thus be regarded as an andesitic series of quite abnormal sodic composition (Barth and Holmsen, (4), p. 13). On the other hand, the King George Island and Bridgeman Island suite, together with the block of doleritic basalt (no. 8) from Deception Island, constitutes a quite normal series of pyroxene-andesites ranging to olivine-basalt, with accompanying plutonic types, and belongs to the great circum-Pacific petrographic region of which the characteristic lava type is hypersthene-augite-andesite.

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[1] E. Gourdon, 'Sur la constitution minéralogique des Shetland du Sud (Île Déception)'. *C.R. Acad. Sci., Paris*, CLVIII, 1914, pp. 583–6.

The Deception Island series. It is difficult to match the rocks of the Deception Island series with those of other andesitic fields. Very occasionally one finds soda-rich andesites as, for example, in the Andean petrographic region, and in that of western North America; but the more normal andesitic types are overwhelmingly predominant in these regions. As a suite the Deception Island rocks are almost unique. The only other series which approaches them in richness in soda is that of the Santorin volcano in the Aegean Sea, as has already been pointed out by Barth and Holmsen. But even among the Santorin analyses only two are closely comparable to the 'santorinite' of Deception Island. In Table 2, col. B, the closest Santorin analogue of the Deception Island santorinite (Table 2, col. A) is tabulated. It agrees closely with the Deception Island analysis except for silica, which is 3 per cent lower. The von Wolff parameters also show concordance except for *Q*. Even Santorin is not a very close analogue for the Deception Island volcano, as is shown by the average of eleven accordant analyses of the lavas of that volcano (Table 2, col. C). The Deception Island rock is distinctly richer in soda and silica, and poorer in potash than that of Santorin.

Table 2. *Deception Island 'santorinite' and comparable analyses*

	A	B	C	D	E
SiO_2	68·33	64·99	65·9	69·00	66·05
Al_2O_3	14·94	14·32	15·8	14·48	13·29
Fe_2O_3	1·94	1·30	1·6	1·25	3·22
FeO	2·67	4·01	3·4	1·01	5·07
MgO	0·52	1·12	1·0	0·36	1·36
CaO	2·08	3·94	3·5	2·34	0·50
Na_2O	6·47	6·20	5·1	6·00	6·67
K_2O	1·94	1·99	2·1	2·76	0·87
H_2O^+	0·16	0·05	0·4	2·19	1·88
H_2O^-		nil			0·96
TiO_2	0·76	2·23	1·0	—	0·49
P_2O_5	0·12	0·01	0·1	0·24	0·09
MnO	—	0·07	0·1	—	? tr.
S	—	—	—	—	? tr.
Cl				—	? tr.
	99·93	100·23	100·0	99·63	100·45
Q	20·2	14·2	20·6	21·8	20·8
F′	65·3	63·0	54·8	67·7	62·8
M′	14·5	22·8	24·6	10·5	16·4
nak	84·9	86·4	67·1	89·4	93·5
k	16·1	17·3	21·1	23·7	7·8

A. Average santorinite, Deception Island (Table 1 *a*).
B. Hyalodacite, east lava flow, August 1925, Fouqué Kaimeni, Santorin, Aegean Sea. Quoted from H. S. Washington, 'Santorin Eruption of 1925', *Bull. Geol. Soc. Amer.* XXXVII, 1926, p. 378.
C. 'Santorinite', average of eleven analyses of the Recent lavas of Santorin volcano, Aegean Sea.
D. Biotite-andesite, Inca-loma, Cotopaxi, Ecuador. A Young, *Hochgeb. Republik Ecuador*, II, 1904, p. 256. Quoted from Washington's Tables (*op. cit. supra*), p. 154.
E. Keratophyre, Trevennen, St Goran, Cornwall. Quoted from *Chem. Anal. Ign. Rocks, etc Geol. Surv. Gt. Brit.* 1931, p. 85.

Among Andean andesites the biotite-andesite of Inca-loma, Cotopaxi (Table 2, col. D) provides a close comparison with the santorinite of Deception Island. Further, some rocks of the keratophyre-spilite association are chemically similar to those of the Deception Island series, as is shown by an analysis of a Cornish keratophyre (Table 2, col. E); but the *k* ratio of this rock is notably smaller, and the *nak* ratio higher, than those of the Deception Island rock (see also Table 4).

The intermediate rocks of the Deception Island series are even more difficult to match. The oligoclase-andesite (Table 3, col. 4) can be paralleled, and that not very closely, by an andesite from the Sincholagua volcano in Ecuador (Table 3, col. F), and by a trachytic andesite from the Recent lavas of the Modoc Quadrangle, California (Table 3, col. G). The bandaitic pillow-lava of Deception Island (Table 3, col. 5) can be most closely compared with a hypersthene-augite-andesite from Grenada, B.W.I. (Table 3, col. H); and less closely, at least in respect of the *nak* and *k* ratios, with an andesitic ash from Cotopaxi, Ecuador (Table 3, col. I). It is to be noted that the Ecuadorian volcanoes have provided two of the comparable analyses in Table 3. It would appear that the andesites of these volcanoes are more sodic than the usual run of Andean andesites. It is interesting to find, also, that an augite-hypersthene-andesite from the Aegean region (Table 3, col. J) has some chemical characters in common with the bandaite of Deception Island.

Table 3. *Intermediate lavas of Deception Island and comparable analyses*

	4	F	G	5	H	I	J
SiO_2	60·62	58·82	59·98	56·89	56·51	56·89	54·53
Al_2O_3	16·22	16·35	16·71	16·07	14·07	19·72	13·06
Fe_2O_3	1·76	5·50	2·52	1·81	4·04	4·06	6·85
FeO	5·67	2·36	5·04	7·08	4·65	3·65	4·86
MgO	1·62	4·37	2·22	2·79	3·95	1·91	3·14
CaO	4·18	4·06	4·84	5·89	8·44	5·87	9·83
Na_2O	6·25	5·31	5·12	5·89	5·32	5·14	4·62
K_2O	1·20	2·02	1·63	0·94	0·79	1·96	1·59
H_2O	0·56	1·05	0·19	0·56	1·51	0·62	0·52
H_2O				0·08			
TiO_2	1·54	0·36	1·30	1·79	0·19	tr.	0·96
P_2O_5	0·24	0·25	0·43	0·21	0·23	tr.	—
MnO	—	—	0·11	0·08	tr.	—	—
S		—	—	0·06	—	tr.	—
Cl	—	—	—	—	—	tr.	—
	99·86	100·45	100·09	100·14	99·70	99·82	99·44
Q	8·1	7·6	11·2	1·9	3·4	3·8	3·9
F′	60·5	56·5	52·4	55·2	49·5	56·4	48·3
M′	31·4	35·9	36·4	42·9	47·1	39·8	47·8
nak	71·7	65·8	60·4	66·4	68·1	53·9	71·1
k	11·4	19·8	17·2	9·5	9·6	20·2	18·7

4. Oligoclase-andesite, Deception Island (Table 1, col. 4).
F. Pyroxene-andesite, Ceballos-chupa, Sincholagua volcano, Ecuador. A. Young, *op. cit. supra*, p. 248. Quoted from Washington's Tables, *op. cit. supra*, p. 452.
G Trachytic andesite (Platy Andesite Group), south of Medicine Lake, Modoc Quadrangle, California. H. A. Powers, 'The Lavas of the Modoc Lava-bed Quadrangle, California', *Amer. Min.* XVII, 1932, p. 292.
5. Bandaite (hypersthene-augite-andesite), pillow-lava, Deception Island (Table 1, col. 5).
H. Augite-hypersthene-andesite, Grenada, B.W.I. J. B. Harrison, *Rocks and Soils of Grenada*, 1896, p. 10. Quoted from Washington's Tables, *op. cit. supra*, p. 466.
I. Andesitic ash, Cotopaxi, Ecuador. J. W. Mallet, *Proc. Roy. Soc.* XLII, 1887, p. 2. Quoted from Washington's Tables, *op. cit. supra*, p. 764.
J. Augite-hypersthene-andesite, Mt Kouragio, Aegina, Greece. H. S. Washington, 'A Petrographical Sketch of Aegina and Methana, Part III', *J. Geol.* III, 1895, p. 150.

It will be noted that all the Deception Island rocks and the comparable types dealt with in Tables 2 and 3 have been characterized by a ratio F'/M' greater than unity. In the remaining rocks of the Deception Island series, the andesitic basalts (Table 4, cols. 6, 7), however, this ratio is less than unity. The andesine-basalt (Table 4, col. 6) is closely comparable with another Ecuadorian lava, a basalt from the Ruminahui volcano (Table 4, col. K). Some spilites as, for example, those of Oregon (Table 4, col. L), are also quite similar. The basalt ('Labradorite'—Gourdon) of Deception Island (Table 4, col. 7) differs from the andesine-basalt only in its positive *Q*. Comparable analyses are those of a hornblende-soda-andesite-basalt, an inclusion in dacite lava from the San Franciscan volcanic field of Arizona (Table 4, col. M), and a hypersthene-augite-andesite from the Czerhát Mountains of Hungary (Table 4, col. N). These rocks, however, are only isolated examples of the type, for in both the Arizona and Hungarian fields the great majority of the andesites otherwise comparable to the Deception Island rocks have a much higher *k* ratio.

Table 4. *Andesitic basalts of Deception Island and comparable analyses*

	6	K	L	7	M	N
SiO_3	52·93	52·92	53·15	53·50	53·97	52·80
Al_2O_3	15·86	16·66	14·39	17·62	16·00	19·44
Fe_2O_3	2·01	4·76	1·28	2·58	4·56	3·47
FeO	8·90	4·89	9·33	6·07	3·63	5·15
MgO	3·63	7·96	4·74	4·39	6·36	2·33
CaO	7·60	5·71	7·04	9·22	7·47	8·70
Na_2O	5·03	5·12	4·58	4·15	4·38	4·71
K_2O	0·64	0·89	1·01	0·75	1·23	1·12
H_2O^+	0·42	0·80	2·02	0·00	1·31	1·26
H_2O^-	0·04		0·19		0·03	0·21
CO_2	—	—	0·10	—	nil	
TiO_2	2·29	—	1·50	1·65	1·46	1·05
P_2O_5	0·35	0·78	0·19	0·36	0·10	0·24
MnO	—	—	0·14			0·11
SO_3	—	—		—	nil	
Cl	—	—		—	tr.	
	99·87	100·49	99·66	100·29	100·50	100·59
Q	−1·0	−3·6	−1·5	2·0	2·0	0·3
F′	46·2	47·5	44·9	39·0	43·8	47·5
M′	54·8	56·1	56·6	59·0	54·2	52·2
nak	56·4	56·1	60·3	43·1	53·5	46·3
k	8·0	10·9	12·9	10·1	15·5	13·6

6. Andesine-basalt, Deception Island (Table 1, col. 6).
K. Basalt, Panang Hondon, Ruminahui volcano, Ecuador. A. Young, *op. cit. supra*, p. 243. Quoted from Washington's Tables, *op. cit. supra*, p. 538.
L. Spilite, Poorman Mine, Oregon. J. Gilluly, 'Keratophyres of Eastern Oregon and the Spilite Problem', *Amer. J. Sci.* XXIX, 1935, p. 235.
7. Basalt ('Labradorite'—Gourdon), Deception Island (Table 1, col. 7).
M. Hornblende-soda-andesite-basalt, inclusion in hornblende-soda-dacite, Bill Williams Mt, San Franciscan Volcanic Field, Arizona. H. H. Robinson, 'The San Franciscan Volcanic Field, Arizona', *U.S.G.S. Prof. Paper* 76, 1913, p. 147.
N. Hypersthene-augite-andesite, Czerhát Mountains, Hungary. A. Vendl, 'Über die Pyroxenandesite des Czerhátgebirges (Ungarn)', *Min. u. Petr. Mitt.* XLII, 1932, p. 516.

The Deception Island series has been treated at some length because, chemically at least, it appears to be almost unique among andesitic series, especially in its richness in soda. As a series, only that of the Aegean volcano Santorin approaches it in chemical character, although sporadic examples of similar rocks occur in andesitic regions of the normal type, and especially among the volcanoes of Ecuador.

It is not necessary to deal with the King George Island and Bridgeman Island series in such detail, for it consists of perfectly normal andesites and basalts conforming closely in their minerals and chemistry with the great circum-Pacific granodiorite-andesite region, and other similar regions (western

North America, Hungary, New Zealand, etc.). The hypersthene-andesite of Admiralty Bay (Table 1 *b*, col. 9) closely accords, except for lower potash, with an average hypersthene-andesite computed by the author from 114 analyses derived from the circum-Pacific region, including the East and West Indies, and certain European fields (Sardinia, Hungary, Aegean Sea).[1] The quartz-gabbro (Table 1 *b*, col. 10) agrees well with an average of 11 analyses of rocks so called taken from Washington's Tables (*op. cit. supra*).[2] The tholeiitic basalts of the series (Table 1 *b*, cols. 11, 12, 14) are accordant with the average Non-porphyritic Central Magma-type of Mull,[3] and with as yet unpublished average analyses of tholeiitic types from the Tertiary igneous region of Scotland. They also accord with the sparsely developed basalts which are found in the great andesitic regions.

The above-mentioned rocks are all over-saturated with silica (positive Q); and in this respect the under-saturated olivine-basalt ($Q \; - 5{\cdot}2$) of the newly discovered Penguin Island volcano (King George Island) stands quite apart from the rest. With M', 80·2, it is also the most basic lava type from the South Shetland Islands so far analysed. Its closest analogue appears to be the olivine-basalt or 'plateau-magma type' of the Tertiary igneous series in Scotland,[4] although it is richer in alumina and lime and poorer in the ferromagnesian oxides than that type, and is thus richer in plagioclase feldspar and poorer in olivine. It is precisely in these chemical and mineral characters that the comparatively rare basalts occurring in andesitic regions differ from the olivine-basalts which are the most abundant and characteristic types of oceanic regions and of many mildly and richly alkaline regions on the continents. Thus the olivine-basalt of Penguin Island preserves its relationship with the associated andesites, notwithstanding its superficial similarity to the olivine-basalts of quite different petrographical regions.

CONCLUSIONS ON THE GEOLOGY OF THE SOUTH SHETLAND ISLANDS

A synopsis of the geology of the Danco Land Coast (Graham Land), the Palmer Archipelago, and the South Shetland Islands was given in my memoir of 1921 ((1), p. 75). The following are relevant excerpts from that summary:

> The oldest rocks in the region (excluding a possible basement of crystalline schists and gneisses) appear to be a series of folded bluish slates and mudstones, with subordinate fine-grained sandstones and greywackes, and abundant intercalations of coarse breccias made up principally of igneous fragments.... The igneous breccias... may possibly be as much due to the rapid denudation of an earlier range of porphyry mountains under arid conditions, as to explosive igneous action....
>
> Because of the abundance and size of the plutonic masses the sedimentary series is only visible in small fragmentary exposures on the Danco Land coast. It appears, however, to occur in great force on the islands of the Palmer Archipelago, in which the igneous breccias are also especially prominent. The sedimentary series constitutes a large part of the South Shetland Islands, especially King George Island. Blue mudstones are intercalated with the older andesites around Admiralty Bay, and are intersected and metamorphosed by the intrusion of Noel Hill, in Marian Cove....
>
> The presumably Mesozoic mudstones are interbedded with an early series of andesite lavas in King George Island, and possibly also in the other islands of the South Shetland group. The plutonic masses of Noel Hill and Le Poing intersect and cause hornfelsing in both sediments and lavas....
>
> The next event in the geological history of the region seems to have been the extrusion of a great series of later andesites, which, in King George Island, are regarded by Mr Ferguson as being banked up against the older series and interbedded mudstones to the north-west. An eruptive focus of this period is probably to be seen in Three Brothers Hill, Potter's Cove, a columnar plug of typical fresh bandaite lava....

[1] G. W. Tyrrell, 'The South Sandwich Islands. Report on Rock Specimens', *Discovery Reports*, III, 1931, p. 195.

[2] G. W. Tyrrell, *The Principles of Petrology*, 1926, p. 120.

[3] 'Tertiary and Post-Tertiary Geology of Mull', *Mem. Geol. Surv., Scotland*, 1924, p. 17.

[4] G. W. Tyrrell, 'The Geology of Arran', *Mem. Geol. Surv., Scotland*, 1928, p. 121.

> The latest volcanic episode seems to have been the extrusion of olivine-basalt lavas mainly from a series of volcanoes in the north-west side of Bransfield Strait (Deception Island; Edinburgh Hill, Livingston Island; Bridgeman Island). These volcanoes are largely built of basalt tuffs with subordinate basalt lavas and intrusions. Deception Island, however, contains hyalodacites and oligoclase-trachytes, as well as basalts. Nordenskjöld (*Antarctis*, 1913, p. 11) suggests that these volcanoes may have some relation to the subsidences of the Bransfield Strait region.... He regards the Bransfield Strait volcanoes also mainly as of early Quaternary age; but Deception Island, and probably Bridgeman Island, continued erupting until recent times....
>
> The main addition we have been able to make to Nordenskjold's account of the region is the recognition of folded sediments in the South Shetland Islands, similar to those of the Palmer Archipelago and the Danco Land coast, but here interbedded with, and covered by, typical Andean lavas. It seems probable that a tectonic zone parallel to those of the Palmer Archipelago and Graham Land runs through the South Shetland Islands. It is worthy of note that the intensity of plutonic action diminishes towards the outer (north-western) part of the region. Plutonic rocks build up the greater part of the mainland ranges; they are also abundant in the Palmer Archipelago, but folded sediments are here also very conspicuous, while in the South Shetlands plutonic masses are small and isolated, and very subordinate in bulk to the sediments and lavas. Conversely the volcanic rocks are very largely confined to the South Shetlands, and are rare in the Palmer Archipelago and the Danco Land coast.

The new Discovery II collections described in this memoir make it clear that King George Island, at any rate, and probably all the larger islands, are mainly composed of the older series of andesites, dacites, rhyolites, etc., with their tuffs, volcanic breccias and agglomerates, which are interbedded in places (Admiralty Bay; Marian Cove) with argillaceous and arenaceous sediments, all conjecturally of late Mesozoic age. This series is intersected by a number of tonalite, diorite and gabbro intrusions. Although Ferguson (*op. cit.* p. 37) has tabulated a thick section of the older andesites, tuffs, agglomerates and sediments in Admiralty Bay, it seems possible that the importance of the sedimentary intercalations has been exaggerated in previous accounts. Ferguson himself collected only a very few of these sediments, and other collections from many localities in King George Island have not included any. If the sediments had been at all prominent in the field, it seems likely that they would have bulked much more largely in the collections, notwithstanding their inconspicuousness in contrast with the more spectacular igneous rocks.

On the other hand, the importance of the plutonic intrusions in the make-up of the South Shetland Islands may have been minimized in previous accounts. The Discovery II collections have brought to light the existence of a large mass of diorite on the eastern coast of King George Island; and diorite seems to form a part of the previously unknown Snow Island. Diorites are also known to occur in Livingston Island, Greenwich Island, and Nelson Island. These rocks are certainly intrusive into the older series of andesites and sediments, as shown by their contact-metamorphic effects. It may be conjectured that these plutonic masses are the underground equivalents of the later and fresher series of andesite lavas which appear to be unconformably banked up against, and superposed upon, the older andesite series. That a long period of erosion succeeded the extrusion of the older series is shown by the occurrence of large erratics of coarse conglomerate at Martin's Head (p. 49), which contain well-rounded boulders of the older andesite, altered tonalite, and comparatively fresh augite-andesite. Since the last-named contains the blue apatites characteristic of the older series of lavas, it is a reasonable assumption that all the boulders and pebbles belong to the older series.

The latest volcanic episode is represented by a series of Quaternary or Recent volcanoes along Bransfield Strait, the craters of which are still well preserved. It is probable that the Deception Island and Bridgeman Island volcanoes have erupted within historical times (Ferguson, *op. cit.* pp. 36, 45). A very notable addition to our knowledge has been provided by Mr Marr's discovery of the Penguin Island volcano (p. 45). The lavas of Penguin Island and Bridgeman Island are olivine-basalts. Olivine-basalt was also erupted at Deception Island; but the main products from this volcano were slaggy and glassy andesites of peculiar composition (p. 54).

Another noteworthy addition to our knowledge made by recent Discovery II expeditions is the existence of several basaltic volcanoes on the north-western side of the South Shetland Islands. Desolation Island, off the northern coast of Livingston Island, consists of columnar basalts of Recent aspect. On McFarlane Strait, not very far to the east, is the beautiful columnar basalt plug surmounted by agglomerate of Edinburgh Hill, discovered and figured by Ferguson (*op. cit.* pl. i, fig. 1). Then again at Fort William, Coppermine Cove, on Roberts Island, the islands at the northern end of Fildes Strait, and on the mainland of King George Island along Fildes Strait, fresh columnar olivine-basalts were collected which probably mark the sites of Quaternary or even Recent volcanoes. All these volcanic centres on the north-western side of the South Shetlands have obviously suffered considerable denudation, and are therefore somewhat older than those on the Bransfield Strait side. There can be no doubt but that these occurrences will be augmented in number when the geological survey of the South Shetland Islands is carried out in detail.

Finally, it is possible that the South Shetlands rest on a basement of crystalline schists and gneisses, with sedimentary rocks in various stages of cataclastic metamorphism. Boulders and pebbles of these rocks are numerous in shore and glacial accumulations, and among the dredged material from Bransfield Strait (p. 57). Quite possibly some of this material has been derived from exposures on the South Shetland Islands, although it is more probable that the bulk of it has come either from the Graham Land peninsula to the south-east or from the Palmer Archipelago to the south.

PART II. PETROGRAPHY OF ROCKS FROM THE GRAHAM LAND PENINSULA AND ADELAIDE ISLAND, WEST ANTARCTICA

INTRODUCTION

Among the material sent me for description by the Discovery Committee during recent years I found small collections of rocks from Cape Roquemaurel, Wiencke Island, and the Marin Darbel Islands, as well as a large collection of stones dredged a few miles off the west coast of Adelaide Island. Dr N. A. Mackintosh kindly provided me with a copy of the short geological notes he had made on Cape Roquemaurel and Port Lockroy in Wiencke Island. These notes have been incorporated with suitable acknowledgement in the following descriptions. The collections, especially that from Adelaide Island, have proved valuable in extending our knowledge of the geology of West Antarctica, and in providing confirmatory evidence in favour of previously expressed views on the relationships of West Antarctic rocks with those of the southern Andes in Patagonia and Tierra del Fuego.

PETROGRAPHY

STATION 1490 (20 JANUARY 1935), CAPE ROQUEMAUREL, TRINITY PENINSULA, GRAHAM LAND

Cape Roquemaurel is situated on the northern coast of the Trinity Peninsula, the eastern termination of Graham Land, in long. 58° 30′ W., lat. 63° 30′ S. In his notes on this locality Dr Mackintosh states that: 'The headland consists of several high rocks projecting from the ice-sheet of Trinity Peninsula. On the south-west side of the outermost rock is a good boat harbour with a very small beach. The rocks of the headland are said to be about 600 ft. high, and consist of a pale granite-like rock traversed by conspicuous dikes of fine-grained blackish rock. On the south-west side of the headland beneath the granite (?) a yellowish brown rock could be seen for several hundred yards just showing itself above the water line. This seemed to be a different kind of rock, though its structure

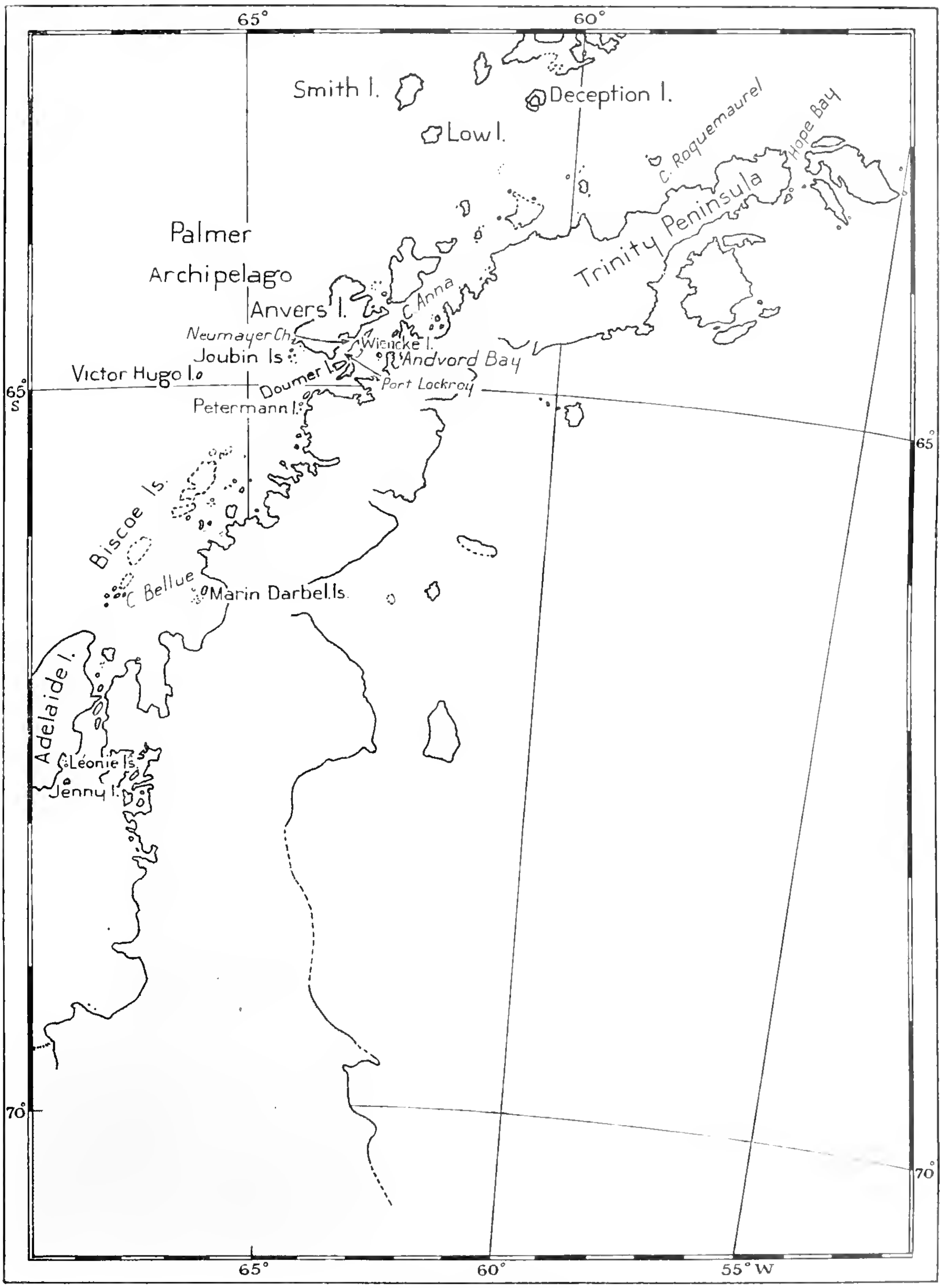

Fig. 9. Graham Land.

and cleavage [jointing?] did not look much different from the crystalline rocks above it.' [This may have been a discoloration of the granite due to intensified weathering between tide-marks.—G.W.T.]

Dr Mackintosh collected four specimens from this locality, two from the main rock formation (granite), and two from dikes. He remarks that the granite showed some variation within short distances, especially in the proportions of the darker minerals, and that his two specimens may have a smaller proportion of the dark minerals than is typical of the rock as a whole.

The main rock is a true granite consisting of quartz, orthoclase, albite-oligoclase, and a very small amount of biotite largely replaced by pale green chlorite. One of the specimens is very coarse-grained, the crystals ranging from $\frac{1}{4}$ in. to $\frac{1}{2}$ in. in greatest diameter. The feldspar is pinkish white and the quartz milky blue in colour. The other specimen is finer in grain and shows a white vein of aplite with a knife-edge contact against the granite.

In thin section the feldspars are seen to be thickly dusted with kaolinitic and sericitic alteration products. The orthoclase seems to be almost pure, with only obscure traces of albite lamellation. The albite-oligoclase occasionally shows an approach to the typical chequer-twinning, and is subordinate in amount to the orthoclase. The quartz and feldspars are sometimes intergrown in a coarse and obscure graphic structure, especially in the finer-grained specimen. The only ferromagnesian constituents are a very few flakes of chloritized biotite. The aplite vein consists of a very fine-grained base of quartz and sericitized orthoclase with a saccharoidal texture, which carries small micro-phenocrysts of quartz, orthoclase, and albite. It is quite devoid of coloured constituents.

Conspicuous dikes of a blackish rock traverse the granite. One of Dr Mackintosh's specimens is 'probably characteristic of all the black dikes in the headland'. In hand specimen it is a fine-grained dark grey rock with a few large fresh phenocrysts of feldspar and a sprinkling of pyrites. In thin section it consists mainly of a panidiomorphic plexus of andesine feldspar and a pale green hornblende in about equal amounts. In addition, there are a few phenocrysts of labradorite (extinction 30°), a little quartz, and numerous fine-grained irregular aggregates of a reddish brown biotite which, in many cases, are apparently growing at the expense of the hornblende. As these aggregates are invariably associated with pyrites, they are probably of secondary origin, and connected with the ingress of sulphide solutions into the rock. This rock is identical with some of the lamprophyres described by Rosenbusch as *spessartite*.[1]

The remaining dike specimen was taken from the inner portion of what is probably a composite dike. This dike was of the same blackish tint as the others. It was about 8 ft. thick, and had a central part of greenish colour and a foot in width. This, however, is only a surface coloration. When broken, the fresh rock is of a greyish blue colour and is very dense, with a flow-banding delineated by the alinement of small pink feldspar crystals. In thin section it proved rather hard to interpret owing to its denseness and opacity. It appears to consist mainly of straight-extinguishing feldspar microlites (? oligoclase) arranged in a wavy flow-banding, with somewhat larger feldspars (? orthoclase), and quartz in smaller quantity. The feldspars are all highly sericitized. In this ground-mass material there are embedded micro-phenocrysts of quartz, oligoclase, and a few pseudomorphs in pale green fibrous hornblende of what may have been an earlier amphibole. As some epidote is always associated with the oligoclase, the original crystals were probably of a more calcic composition. On the whole, the rock has the mineral composition of a dacite. Perhaps an earlier generation of petrographers would have called it quartz-porphyrite.

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[1] Osann-Rosenbusch, *Elemente der Gesteinslehre*, 4th ed. 1922, p. 333.

PORT LOCKROY, WIENCKE ISLAND

Port Lockroy is a small harbour on the west coast of Wiencke Island, opening out on to the Neumayer Channel which separates the large Anvers Island from Wiencke Island. Rocks from Wiencke Island and Doumer Island, as well as from the islands in the Neumayer Channel, and on the south and west of Wiencke Island, have been collected by several expeditions. Thus Pelikan[1] described quartz-diorite and gabbro, the former cut by diorite-porphyry and diabase dikes. Gourdon[2] described quartz-mica-pyroxene-diorite, quartz-diorite, and micro-diorite, with numerous 'labradorite' (hornblende-andesite) dikes penetrating the quartz-diorite massif. Ferguson wrote: 'Wiencke Island is bounded on the side facing Neumayer Channel by almost vertical walls of sedimentary rocks including bluish black mudstone; it is, however, largely formed of gray diorite, which is the only rock present in Doumer Island and the Cairn Islands.'[3] From Ferguson's collection the writer described tonalite, igneous breccias, and a siliceous mudstone.[4]

The most recent work on the petrography of this part of the Palmer Archipelago is that of T. Barth and P. Holmsen.[5] They described eucrite and anorthosite (with chemical analyses) from an islet near Victor Hugo Island (west of Wiencke Island). The Joubin Islands, also west of Wiencke Island, consist mainly of igneous breccias, and an analysis is given of a prehnitized rock fragment from these breccias. From Port Lockroy, Barth and Holmsen described quartz-diorite and adamellite, with analyses. They remark that the whole region from Port Lockroy westward to the Joubin Islands and Victor Hugo Island is penetrated by 'diabase' dikes. The general picture of the geology of this region is then that of an ancient basement consisting of sediments and igneous breccias, cut by plutonic intrusions of tonalite and adamellite, the whole being penetrated by numerous dikes, especially 'diabase'.

Dr Mackintosh collected two rock specimens from an island in Port Lockroy harbour. Both consist of tonalite identical with that described by me from Ferguson's collection, but the larger specimen shows a sharp contact of tonalite with a dike of fine-grained grey micro-porphyritic rock which is a porphyritic micro-tonalite. In thin section the tonalite shows biotite, hornblende, and magnetite as mafic constituents, with very abundant euhedral plagioclase (andesine, An_{40}), all of which are embedded in a coarse ground-mass consisting of interlocking crystals of quartz with subordinate orthoclase. Biotite and hornblende are present in roughly equal amounts. The hornblende is variegated in shades of green, the larger crystals breaking up into aggregates of smaller, differently coloured grains.

The dike rock shows numerous phenocrysts of andesine with heavy mechanical zoning, and somewhat fewer phenocrysts of a fibrous, pale green hornblende, enclosed in a very fine-grained equigranular ground-mass consisting of quartz, orthoclase, andesine, hornblende, biotite passing into chlorite, and cubes of magnetite. It is a quartz-diorite porphyry or tonalite-porphyry; or, if it be desirable not to use the ambiguous term 'porphyry', it may be designated as porphyritic micro-tonalite.

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[1] A. Pelikan, 'Petrographische Untersuchungen der Gesteinsproben', *Résultats du Voyage de S.Y. 'Belgica', Expéd. Antarctique Belge; Geologie*, Anvers, 1909.

[2] E. Gourdon, 'Géographie physique, Glaciologie, Pétrographie', *Expéd. Antarctique Française*, 1903–5, Paris, 1908.

[3] D. Ferguson, 'Geological Observations in the South Shetlands, the Palmer Archipelago, and Graham Land, Antarctica', *Trans. Roy. Soc. Edin.* LIII, 1921, p. 49.

[4] G. W. Tyrrell, 'A Contribution to the Petrography of the South Shetland Islands, the Palmer Archipelago, and the Danco Land Coast, Graham Land, Antarctica', *ibid.* pp. 59, 73, 74.

[5] 'Rocks from the Antarctandes and the Southern Antilles', *Scientific Results of the Norwegian Antarctic Expeditions* 1927–28 *and* 1928–29, *instituted and financed by Consul Lars Christensen*, No. 18, Norske Vidensk.-Akad., Oslo, 1939, pp. 17–33.

THE MARIN DARBEL ISLANDS

This group of small islands and rocks lies a few miles south-west of Cape Bellue at about long. 66° 20′ W., lat. 66° 00′ S. In a brief note accompanying the specimens, in which the above location is given, they are wrongly allocated to the Biscoe Islands, which form a long chain of islands north-east of Adelaide Island. The above-given latitude and longitude are those of the Marin Darbel Islands. I have been able to find no previous reference to the geology of these islands.

The specimens collected are stated to come from a small uncharted island lying to the south-west of Cape Bellue. This island, like all those in the vicinity, consists of an ice-worn mass of igneous rock. Two large specimens of this rock (norite) were taken; five others represent dikes penetrating it.

The main rock of the island is a coarse plutonic type of a mottled, greenish grey tint, consisting of white feldspars and greenish black ferromagnesian minerals. In thin section the appearance of coarse grain is seen to be illusory, for the rock consists of large areas of fresh labradorite (An$_{55}$) in small crystals, alternating with larger and more isolated crystals of hypersthene, augite, and magnetite. The hypersthene is mainly fresh and distinctly pleochroic, but some crystals are in process of alteration to a pale green fibrous bastite mineral, and a few to brown biotite, both modes of alteration being accompanied by the disengagement of magnetite. There is also some primary iron ore. The hypersthene is apparently slightly preponderant over the pale diopsidic augite, and the periods of crystallization of the two minerals appear to overlap. Thus the rock is a norite or more exactly a hyperite, since the hypersthene is accompanied by a notable amount of monoclinic pyroxene. In another specimen the hypersthene has gone over completely to bastite.

Three of the dike rocks are dark, greenish grey, aphanitic types in which numerous micro-phenocrysts of serpentinized olivine and feldspar can be made out with the lens. In thin section they turn out to be olivine-basalts with very numerous micro-phenocrysts of bytownite (An$_{90}$) and almost equally numerous olivines which are perfectly euhedral but completely altered to pale green serpentine. The ground-mass is very minutely crystalline, and consists of microlites of plagioclase, augite, and magnetite. Numerous spherical steam cavities are present which are usually filled with fibrous, radiating, pale green delessite. A fourth specimen is much coarser and is highly carbonated. It appears to represent a coarse basalt or dolerite.

That part of the Graham Land peninsula and the Palmer Archipelago which lies between lat. 64°–67° S. and long. 62°–66° W. seems to be rich in gabbroic intrusions and basic dikes. Thus Pelikan (*op. cit. supra*) described gabbros and dolerite dikes from Anvers Island, Bob Island (off south coast of Wiencke Island), and Cape Anna (Danco Land). Gourdon, likewise (*op. cit. supra*) described basalt dikes from Wiencke Island and Doumer Island, diabase dikes from Booth Island (Wandel I.), diabase and gabbro from Petermann Island and Cape Tuxen. From the Andvord Bay region the writer (*op. cit. supra*) described basalt dikes and an intrusion of fresh olivine-gabbro (Bruce Island). Barth and Holmsen (*op. cit. supra*) commented on the abundance of basic dikes in the region between Victor Hugo Island and Port Lockroy (i.e. along the line of lat. 65° S.), and described eucrite and anorthosite from Victor Hugo Island.

ADELAIDE ISLAND

Adelaide Island is a large island off the coast of Graham Land at about lat. 67° S., long. 69° W. Geologically nothing is known of the main island, but the French Expedition of 1903–5 collected rock material from three small islands, Jenny, Léonie, and Webb Islands, off its south-eastern coast. Gourdon (*op. cit. supra*) described them as consisting of gabbro cut by numerous dikes of basalt, diabase, and andesite, and has given no fewer than ten analyses of these rocks.

Among the first set of Discovery II material sent me I found a box of stones dredged from St. 599, off the west coast of Adelaide Island at a depth of 203 m. The exact position of the Station is lat. 67 08′ S., long. 69 06½′ W. Forty-six of these stones were examined and thin sections made. They ranged in size from boulders 9 in. in greatest diameter to pebbles less than 1 in. across. As these dredgings were taken only a few miles off the western coast of Adelaide Island near the central point of the western coastline, it is likely that many, if not all, were derived from this geologically unknown land.

Ten of the stones belong to the granite family, including ordinary granite, granophyre, granodiorite, and tonalite. Eight are quartz-diorites, three dioritic lamprophyres, and one quartz-gabbro. No fewer than fourteen of the specimens are quartz-porphyries or allied rocks, all of which show signs of crushing and brecciation, in extreme cases reducing them to 'porphyroids' and even to types which might be regarded as metamorphic quartzite. Five of the stones are lavas, including rhyolite, dacite (or dellenite), and andesite. Finally, the collection includes five andesitic breccias similar to those which have been described from other parts of the Antarctandes.

One of the two true granites consists of a coarse-grained allotriomorphic mixture of quartz, micro-perthitic orthoclase, and somewhat less abundant albite-oligoclase which is much more heavily dusted with clayey alteration products than the orthoclase. The sparse ferromagnesian constituents are mainly chloritized biotite, and there are a few crystals of fibrous hornblende.

The second granite, like the first, is of a pale flesh-pink colour, but is of finer grain and obviously richer in dark constituents. The feldspars consist of micro-perthitic orthoclase and oligoclase (Ab_{80}) in roughly equal quantity. The oligoclase frequently forms well-shaped crystals which are enclosed in the larger plates of orthoclase. Both feldspars tend to be poikilitically enveloped in a mosaic of large grains of quartz, and both exhibit coarse intergrowths with quartz. The chief ferromagnesian constituent is biotite which is mostly chloritized. With abundant magnetite, sphene, and apatite, the chloritized biotite mainly occurs in small clots or segregations which appear to be of cognate origin. Both these granites are, strictly speaking, adamellites, as plagioclase occurs to the extent of more than one-third of the total feldspar.

One of the pebbles is a good granophyre consisting almost entirely of a fine micro-graphic intergrowth between quartz and very turbid orthoclase. This encloses a few larger crystals of rounded and embayed quartz. The original ferromagnesian minerals appear to have been biotite, now chloritized, and a few flakes of muscovite; but a later mineralization has brought in some large aggregates consisting of calcite, radial sheaves of muscovite, and irregular masses of pyrites.

Next comes a granitoid rock which bears a considerable resemblance to the second adamellite described above, as it carries the same clots of chloritized biotite, but with epidote and pyrites instead of sphene and magnetite. It differs, however, in its more richly ferromagnesian character, and especially in the relation between the feldspars. In this rock oligoclase occurs in distinctly superior amount to the orthoclase. It is therefore to be classed as granodiorite. Another stone is a porphyritic micro-crystalline variety of this type, and may be called granodiorite-porphyry or porphyritic micro-granodiorite.

Five stones belong to the tonalite group. Tonalite, in the author's opinion, is a granitoid rock intermediate between granodiorite and quartz-diorite, distinguished by its abundant plagioclase relative to orthoclase while retaining an amount of quartz sufficient to exclude it from the quartz-diorite group. Its ferromagnesian constituents are mainly hornblende and biotite. They are more abundant than in the granites and less abundant than in the quartz-diorites.

Each of the five stones assigned to this group conform more or less closely to the above definition. Two of them contain biotite, mostly altered to chlorite and epidote, as their sole ferromagnesian mineral, with magnetite and apatite as accessories. In one of these rocks the biotite is interleaved with narrow lenticles of a colourless mineral of high refraction and birefringence, straight extinction, and good cross-fracture, which is doubtfully identified as sillimanite. The remaining three tonalites have a considerable amount of green hornblende in addition to biotite, and sphene is a rather abundant accessory. One of these rocks, however, has a well-marked granulose structure, and the irregular grey-green plates of hornblende are spotted with rounded inclusions of quartz and feldspars. This is the 'sieve structure' which is often taken as a sign of hybridism.

The diorite family is represented by eight rocks of which six are typical quartz-mica-diorites, consisting of plagioclase (oligoclase to andesine), hornblende, and biotite, with a small residuum of quartz and occasionally a little orthoclase. Magnetite and apatite are the most important accessory minerals, and the apatite often occurs in some abundance as comparatively large crystals. Pyrites, epidote, and chlorite occur as secondary minerals, the two last-named being the products of alteration of feldspar and biotite respectively. The six quartz-diorites vary among themselves within narrow limits in the proportions of dark to light minerals, and in the relative amounts of hornblende and biotite.

The seventh quartz-diorite is distinguished from the above-described by containing a notable amount of colourless augite, which occurs in small clots or segregations with hornblende, biotite, magnetite, and apatite. It is therefore a quartz-mica-augite-diorite of a type approximating to Stelzner's 'andendiorit' from the Argentinian Andes. The eighth rock assigned to the diorite group is a micro-diorite of very fine grain and uniform, allotriomorphic granulose texture, consisting of andesine and green hornblende in about equal quantity. A small amount of biotite is involved with the hornblende as well as a notable quantity of apatite and magnetite, and there is also a small residuum of quartz. This rock may be regarded as a mesocratic quartz-micro-diorite which shows affinity to the malchite of Osann.[1]

Only one of the stones in this collection falls in the gabbro family. It is a medium-grained rock consisting of plagioclase, probably labradorite, but now intensely altered with the production of aggregates of epidote and unidentifiable turbid matter; pale augite, and an almost equal amount of faintly pleochroic hypersthene which is largely altered to chlorite. A little brown hornblende occurs as an alteration product of the augite. Magnetite and apatite constitute the only accessory minerals, together with a small residuum of quartz. This rock may therefore be described as quartz-hypersthene-gabbro or quartz-hyperite. It is probably to be correlated with the quartz-gabbros of the Jenny Island group off the south-eastern coast of Adelaide Island.[2]

The three lamprophyres in the collection all belong to the spessartite group, and consist essentially of green hornblende and andesine with typical panidiomorphic texture. The hornblende is somewhat in excess of the plagioclase. One of the rocks contains numerous phenocrysts and crystal aggregates of hornblende in the lamprophyre ground-mass. Another contains patches of a pale bleached biotite and of pale green chlorite, with a few micro-phenocrysts of feldspar. The third has much chlorite and magnetite, and its hornblende is mostly of the brown variety. All these rocks carry a small residuum of quartz. This group of lamprophyres appears to be abundant in the Graham Land peninsula and the adjacent archipelagos.

We now come to the most interesting and important group of stones from Adelaide Island, namely, the acid volcanic rocks, including rhyolite, dacite, and igneous breccias which contain a variety of acid types. The breccias consist mainly of quartz-porphyry fragments which have suffered cataclastic

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[1] Osann-Rosenbusch, *Elemente der Gesteinslehre*, 4th ed., 1922, p. 321.

[2] E. Gourdon, 'Sur la constitution minéralogique de l'Île Jenny (Antarctica)', *C.R. Acad. Sci., Paris*, 159, 1914, 369-71.

deformation of the same kind as that described by Quensel from the 'porphyry formation' of Patagonia and Tierra del Fuego.[1] Sixteen stones belong to this group.

Three specimens appear to belong to the rhyolite-dacite group. One is a dense whitish rock mottled with pale green streaks which exhibit a rough parallelism. In thin section it becomes clear that this is a coarse and even contorted flow-banding of alternating lighter and darker streaks, more obvious when the slide is held up to the light than when it is viewed through the microscope. The rock consists of a quartzo-feldspathic paste of variable but always fine grain, mingled with varying quantities of sericite and a colourless to palest green, almost isotropic mineral of higher refractive index than quartz or canada balsam. This mineral occurs in reticulated areas with a flaky, fibrous, or vermiculate structure under polarized light. These properties may serve to identify it tentatively as a variety of kaolinite. Sericite and kaolinite are much more abundantly developed in the darker bands, although they are not absent from the lighter streaks. The only other identifiable mineral is some secondary pyrites. The rock is intersected by thin, thread-like, discontinuous veins of secondary quartz. The flow structure may be primary and the rock therefore a rhyolite; but there is the possibility that it is a pseudo-flow structure like that of the quartz-porphyries or porphyroids described later, and due to cataclastic deformation. The facts that some of the larger quartz grains show undulose extinction, and the considerable development of sericite, may perhaps be regarded as in favour of this view.

Another rock appears to be the same as that described by Quensel[2] from Patagonia as 'felsite-porphyry'. This shows small phenocrysts of bipyramidal quartz, orthoclase, and oligoclase, in a largely cryptocrystalline, quartzo-feldspathic ground-mass. There is, however, a large amount of recrystallized quartz forming irregular areas which carry inclusions of ground-mass material, and which impregnate feldspar phenocrysts in their vicinity. Both quartz and feldspar phenocrysts are euhedral, and the latter enclose large, well-developed crystals of epidote and zoisite. The only coloured minerals present are a few areas of leucoxene representing altered ilmenite, and some secondary pyrites. Veins of secondary quartz traverse the rock and cut through some of the feldspar phenocrysts, but appear to merge into the areas of recrystallized quartz in the ground-mass. This rock is a quartz-felsite or quartz-porphyry which differs from those later described in its comparative lack of alteration and in its much smaller proportion of phenocrysts to ground-mass. Its mineral composition roughly corresponds to that of adamellite or granodiorite, and it might therefore, if a lava, be styled dellenite.

A third member of this group is obviously a fragmental rock of composition similar to the above except that plagioclase feldspar is much more abundant. It contains numerous angular chips of rhyolitic or dacitic composition in a uniform cryptocrystalline ground-mass of quartzo-feldspathic composition. The rock has been heavily impregnated with secondary pyrites which has stimulated local silicification of the ground-mass. It is best regarded as a dacitic tuff.

Next come three rocks interpreted as coarse tuffs or igneous breccias consisting mainly of fragments and fine comminuted debris of the rhyolite and quartz-felsite (dellenite) just described. One of them consists mainly of fragments similar in composition and structure to the above rhyolite, but in general of coarser grain. There are nevertheless rapid variations in grain size across barely visible boundaries between adjacent fragments. In fact it was only possible to identify the rock as a rhyolitic breccia through the occurrence of a few angular fragments of a coarse feldspathic type apparently belonging to the granite-porphyry described later. Some of the coarse-grained material may be due to secondary silicification. The two remaining rocks of this group are clearly igneous breccias consisting mainly of fragments of the dellenite above described.

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[1] P. Quensel, 'Die Quarz-porphyr- und Porphyroidformation in Südpatagonien und Feuerland', *Bull. Geol. Inst. Upsala*, XII, 1913, pp. 9-40.

[2] *Op. cit. supra*, p. 14, and fig. 10, p. 27.

The ten remaining stones of the acid volcanic series consist of coarse quartz-feldspar-porphyries and their tuffs or igneous breccias, in which a progressive series of cataclastic deformations have taken place, resulting in the formation of typical 'porphyroids' and, finally, a completely mylonized rock which can only be distinguished with difficulty from a metamorphic quartzite. While the majority of the porphyroids and igneous breccias consist of quartz-feldspar-porphyry fragments only, three contain fragments of rhyolite, felsite, and oligoclase-andesite in subordinate amount.

The series begins with an almost normal, practically unstressed quartz-feldspar-porphyry or granite-porphyry, containing very abundant phenocrysts of quartz, some a centimetre in length, orthoclase not quite so large, and still smaller crystals of albite-oligoclase, in a fine-grained ground-mass of aplitic type which consists of equidimensional crystals of quartz, orthoclase, and albite-oligoclase. A few small crystals of altered biotite and a little iron ore represent the only ferromagnesian constituents. The phenocrysts collectively make up considerably more than half the volume of the rock. Only the large quartz crystals show the beginnings of stress. They are cracked and somewhat rounded, with narrow zones of granulation along the fissures.

Next comes a series of rocks which may be described as igneous breccias consisting of shattered fragments of the above quartz-feldspar-porphyry with, in some cases, a few pieces of rhyolite, quartz-felsite, and oligoclase-andesite. These may, perhaps, be best interpreted as explosion breccias, but they may possibly represent scree material at least in part. All these rocks have been subjected to crushing and shearing stress of varying degrees of severity. The quartz phenocrysts have been shattered and ground-mass material has been forced in between the fragments. Sometimes the fragments have not been so far separated that the outline of the original phenocryst cannot be traced, but in more severe cataclasis the fragments have been dispersed far and wide throughout the ground-mass. Where the stress has not been great the feldspars have retained their crystal forms, but have been more or less completely sericitized. With more severe shearing the feldspars have been broken down and may show more or less rounded fragments enclosed in areas of comminuted and sericitized material. In extreme cases the feldspars are represented merely by elongated areas of sericitized material the margins of which fade out gradually into the ground-mass. The ground-mass itself has been sheared and sericitized in the same way, but owing to its finer grain and its consequent greater mobility under shearing stress, it has been forced to flow round the phenocrysts, producing what Quensel (*op. cit. supra*) has called secondary flow structure. The rocks are then typical 'porphyroids', with elongated strips of felted sericite flakes winding round the broken phenocrysts. Secondary epidote and chlorite have been produced in some quantity, especially in the breccias that contain andesite fragments.

What appears to represent the final stage of cataclastic deformation is reached in a quartzite-like rock which, if seen in isolation away from the associated types, would certainly be regarded as a metamorphic quartzite or quartz-schist. It consists of alternating strips of coarse and fine quartz crystals. Some water-clear plagioclase feldspar is mingled with the quartz of the coarse layers, and a very pale green, almost isotropic chlorite with the fine-grained quartz. The larger quartz crystals interlock with their neighbours along crenulated margins. Chlorite and ilmenite decomposing to leucoxene are somewhat concentrated in restricted areas presumably where fragments of andesite occurred in the original breccia. Patches and veins of clear recrystallized calcite also occur. Not a trace of sericitization is left. Presumably the sericite, together with particles of iron oxide, has been reconstituted into chlorite. This rock is somewhat tentatively identified as the mylonized end-product of extreme cataclastic deformation affecting a breccia composed of acid igneous rocks.

The connected series of rocks above described is thus regarded as a complex of acid lavas, or lavas and intrusions (quartz-feldspar-porphyry, quartz-felsite, rhyolite, dellenite, dacite, and oligoclase-andesite), with their tuffs and explosion-breccias, which has been subjected to extensive crushing and shearing. This complex appears to be identical with that described by Quensel (*op. cit. supra*) from Patagonia and Tierra del Fuego.

The same or a similar complex of acid igneous rocks has also been noted in at least three localities in the Graham Land peninsula and adjacent islands. Thus, O. Nordenskjöld,[1] writing of the loose blocks on the land surface and in the moraines, and of the boulders in the Late Mesozoic and Tertiary conglomerates, found in the northern part of the peninsula, says that they include quartz-porphyries of various types, some showing such a high degree of mechanical metamorphism that they have been transformed into sericite-schists. He remarks the similarity of these rocks to the porphyry formations of Patagonia which he had previously investigated. Again, in 1913, Nordenskjöld[2] stated that at Hope Bay, within the eastern ranges of Graham Land, there occurred acid porphyries and porphyry tuffs apparently concordant with the folded and metamorphosed Jurassic sediments of that locality. He further remarked that these rocks are probably the same as those that form part of the South American cordilleras.

At Hope Bay, on the western side of Antarctic Sound at the northern tip of Graham Land, J. G. Anderson[3] described sediments with Jurassic plants overlain, in Mount Flora, by 200 m. of whitish tuffs derived from acid volcanic rocks.

Finally, E. Gourdon[4] described an erratic from the north of Hovgaard Island as a 'rhyolite with globular quartz', which he regarded as an 'ancient facies' of porphyry. This rock carries porphyritic orthoclase and bipyramidal quartz, and the crystals are associated with sinuous flow lines. The quartz is much corroded and surrounded by aureoles of ground-mass material. The rock, he says, has suffered severe mechanical deformation. It obviously has a close resemblance to the porphyroids of Adelaide Island described above.

The last remaining group of rocks from the Adelaide Island collection consists of oligoclase-andesite lavas, and coarse tuffs or breccias consisting mainly of fragments of the same type. Eight stones are assigned to this group. Two are normal lava types, two are slaggy and vitreous variants, and the remaining four are coarse tuffs or breccias. The lavas exhibit numerous very small micro-phenocrysts of fresh oligoclase, usually with well-marked parallel flow-orientation, embedded in a fine-grained ground-mass consisting of microlites of oligoclase and orthoclase, with chlorite representing the original ferromagnesian mineral (probably augite). This is peppered with numerous, irregularly shaped particles of iron ore.

Slaggy variants of this lava contain much dark glass and are somewhat haematitized. The tuffs and breccias consist of angular fragments of the above-described lava of varying textures, with an occasional flake of mudstone or shale. Furthermore, volcanic mud has infiltrated into the breccias and acts as a scanty cement.

These rocks recall the characteristics of some of the older group of andesite lavas which are so conspicuous in the geological make-up of the South Shetland Islands (Tyrrell, *op. cit. supra* and preceding paper, pp. 43 *et seq.*).

CONCLUSIONS

The rocks from Graham Land and adjacent islands described in the foregoing pages strengthen the already abundant evidence that the igneous rocks of the region, down to the latitude of Adelaide Island at least, are identical with those of the Patagonian Andes. Of particular interest is the discovery

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[1] 'Petrographische Untersuchungen aus dem westantarktischen Gebiete', *Bull. Geol. Inst. Upsala*, VI, 1900, p. 241.

[2] 'Antarctis', *Handbuch der Regionalen Geologie*, Bd. VIII, Abt. 6, 1913, p. 9.

[3] 'On the Geology of Graham Land', *Bull. Geol. Inst. Upsala*, VII, 1906, p. 24.

[4] 'Géographie physique, Glaciologie, Pétrographie', *Expéd. Antarctique Française*, 1903–5, Paris, 1908, p. 163.

of a quartz-porphyry formation which has undergone intense cataclastic deformation in Adelaide Island. This formation, which is of Mesozoic age (older than Upper Cretaceous) in Patagonia, and extends in that country over a belt more than 400 km. in length, is thus shown to continue in Graham Land to a further distance of about 1000 km.

The evidence of this rock collection thus strongly reinforces the conclusion the writer came to in an earlier study, namely, that 'the Graham Land eruptives are identical down to the smallest chemical and mineralogical details with Andean types as far as we know them. The chemical and petrological similarities are so great that one can have no hesitation in subscribing to Nordenskjöld's view that the Graham Land ranges, and those of the contiguous islands, are the continuations in Antarctica of the Patagonian chains.... In Nordenskjöld's expressive phrase, Graham Land is a mirror-image of the southern end of South America.'[1]

PART III. PETROGRAPHY OF ROCKS FROM THE ELEPHANT AND CLARENCE GROUP

The Elephant and Clarence Group of islands, comprising Elephant Island, Cornwallis Island, and Clarence Island, in its northern section, and Gibbs Island, Aspland Island, and O'Brien Island to the south, is usually regarded as a part of the South Shetlands archipelago (see map, Fig. 10). But there is a good case for its separation as an independent group, and for regarding it as on a parity with the South Shetlands and the South Orkneys. There is a wide sea gap between Gibbs Island and King George Island (South Shetlands), much wider than the distances between the individual islands of either group; moreover, the Elephant and Clarence Group is geologically quite different from the South Shetlands with their thick coverings of andesite lavas, which are absent from all the visited islands of the Elephant and Clarence Group.

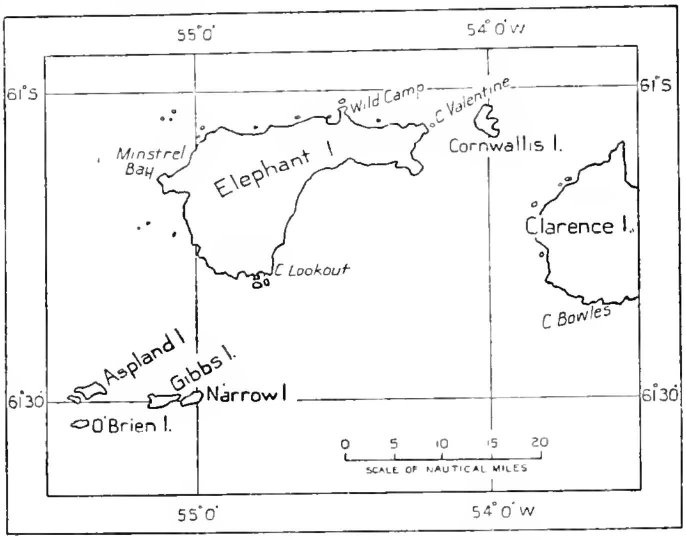

Fig. 10. Elephant and Clarence Group.

Landings on the islands of the Elephant and Clarence Group have been few, and consequently the geological data up to date are very scanty. In the following pages the available information is assembled and supplemented by the investigation of new material from Clarence Island and Gibbs Island, collected during expeditions of the 'Discovery II'.

ELEPHANT ISLAND

During the Salvesen expedition of 1913 the late Mr David Ferguson passed close to Elephant Island, but was unable to land owing to stormy conditions. He made a few observations from the ship, however, and has recorded them as follows:[2] 'The rocks at the south-east corner of the island [Cape Lookout?] are light grey to dark, and more or less banded. The grey rocks appear to be stratified

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[1] G. W. Tyrrell, 'A Contribution to the Petrography of the South Shetland Islands, the Palmer Archipelago, and the Danco Land Coast, Graham Land, Antarctica', *Trans. Roy. Soc. Edin.* LIII, pt. 1, 1921, p. 78.

[2] D. Ferguson, 'Geological Observations in the South Shetlands, the Palmer Archipelago, and Graham Land, Antarctica', *Trans. Roy. Soc. Edin.* LIII, pt. 1, 1921, p. 35.

as the bedding is uniform, but some of the darker rocks may be bedded lavas. [Mr Ferguson was in error here as shown by Prof. Tilley's observations on the Quest Expedition collection—see below.]... Much of the island appears to be formed of stratified sediments. Along the extreme west coast, and some eight to ten miles out to sea, is a series of sea-worn hummocks, roughly banded, with smooth slopes, which resemble dark-coloured, table-topped lavas.' [Seal Islands?]

The first landing by a geologist on Elephant Island was made by J. M. Wordie in 1914 as a member of the party marooned on the island during Sir E. Shackleton's Antarctic Expedition, 1914-17. Although living under very difficult conditions Mr Wordie made rock collections at Cape Valentine, the north-eastern point of the island, and at Cape Wild, 6 miles farther west, which were described by the present writer in a section of Mr Wordie's account of the geology.[1]

The rocks of the north-east coast consist of dark grey, indigo blue, bluish green and grey-green phyllites of fine texture and glossy cleavage surfaces. Many of them are profusely veined and permeated with secondary silica. The rocks consist of quartz, feldspar (plagioclase), chlorite of three varieties, calcite, and opaque greyish (sericitic?) and black (carbonaceous) matter. The calcite is always, the quartz frequently, of secondary origin. These minerals are arranged in thin, elongated, parallel lenses representing a small-scale flaser texture indicative of intense pressure metamorphism. These puzzling rocks are difficult to interpret; some may represent ordinary argillaceous sediments, as Tilley believes from a study of the similar rocks of Minstrel Bay on the west coast (see below), but others may have been fine washes from an andesitic terrain, or even andesitic dusts.

These rocks are highly folded and tilted. At Cape Valentine Mr Wordie states that they dip south by east at about 30°. South of Cape Valentine the rocks dip uniformly to the south and show no folding. Between Cape Valentine and Cape Wild the dip is to the north and changes rapidly from verticality to between 30 and 40°. At Cape Wild the dip of foliation is about 60° towards N. 15° W. At the foot of Mt Houlder (south of Cape Wild) the most striking feature of the section is a reduplication of the beds by 'concertina' folding. There are thus indications of folding on both a small and large scale; small-scale folding and foliation were probably contemporaneous, but the large-scale folding was probably due to a later set of movements.

The Shackleton-Rowett Quest Expedition (1921-2) landed parties at Lookout Harbour at the extreme south of Elephant Island and at Minstrel Bay on the west coast. Rock collections made by Mr G. V. Douglas[2] have been described by Prof. C. E. Tilley.[3]

Tilley describes the rocks from Minstrel Bay as dark grey to leaden grey phyllites, much contorted and penetrated by numerous veins of secondary silica. The constituents are essentially quartz and albitic feldspar, with scales and closely packed films of chlorite and white mica, abundant carbonaceous matter and some granules of epidote. These rocks are regarded as normal sediments, and Tilley thinks there is no reason to believe that volcanic material enters into their composition. These phyllites are correlated with those of the Cape Wild area described by me (above). On G. V. Douglas's map (Tilley, p. 56) signs indicate that the phyllites strike a little south of east and are vertical. Since these phyllites have been found at Minstrel Bay, and in the area between Cape Wild and Cape Valentine, it may be conjectured that the northern coast and perhaps the northern half of the island consists of these rocks.

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[1] J. M. Wordie, 'Shackleton Antarctic Expedition, 1914-17: Geological Observations in the Weddell Sea Area', *Trans. Roy. Soc. Edin.* LIII, pt. 1, 1921, pp. 17-27.

[2] 'Geological Results of the Shackleton-Rowett (Quest) Expedition (Report of lecture)', *Quart. Journ. Geol. Soc.* LXXIX, pt. 1, 1923, Proc. pp. x-xiii.

[3] 'Petrographical Notes on Rocks from Elephant Island, South Shetlands', *Quest Expedition Report*, British Museum (Natural History), London, 1930, pp. 55-62.

On the other hand, the rocks of Lookout Harbour at the extreme south are of markedly different mineral composition and metamorphic grade. According to Tilley they are divisible into three petrographical groups:

(*a*) Garnet-hornblende-albite-schists,
(*b*) Amphibole-bearing marbles,
(*c*) Para-amphibolites.

The rocks of these three groups are linked by the general presence of hornblende, and, to a less degree, albite. Their study, aided by chemical analyses, leads to the conclusion that 'they form a graded series of related sediments ranging from limestones to impure types giving the amphibolites and garnet-hornblende-schists rich in albite'. The original sediments were of abnormal composition, inasmuch as abundant albite was present, probably derived from detrital plagioclase. The grade of metamorphism is obviously much higher than that of the northern phyllites. No data are given of the attitude or geological structure of the Cape Lookout series, which may occupy the southern half of Elephant Island.

CORNWALLIS ISLAND

This is a small island lying in the strait between the much larger Elephant and Clarence Islands. There is no record of a landing, and nothing is known of the geology except a brief note by Mr Ferguson (*op. cit. supra*, p. 35). He says: 'It was not possible to land, but the steamer got very close in. It [Cornwallis Island] rises sheer out of deep water in splintery crests, and is partly covered with snow. The highest point of the island may be 1000 ft. or more above sea level. The slopes are very steep, often quite vertical, and there is consequently much bare rock.... It is formed of light-grey schistose rocks, the foliation planes having a direction [of strike] about N. 70-80° E., with a nearly vertical dip.' Cornwallis Island is not far to the east of Cape Valentine on Elephant Island, where Wordie recorded the strike as east by north, i.e. about the same as that of the rocks on Cornwallis Island. Wordie also says that 'the mountains along the coast [of Elephant Island], when of bare rock, have precipitous slopes and serrated crests of the "frayed cardboard edge" type', which agrees well with Ferguson's description of the topography of Cornwallis Island quoted above. It may therefore be taken as probable that Cornwallis Island represents an eastern continuation of the same rocks as those of the northern coast of Elephant Island.

CLARENCE ISLAND

So far as is known, no geologist had landed on Clarence Island until Prof. O. Holtedahl, in January 1928, managed with some difficulty to get ashore near the northern point (Cape Lloyd) during the Norwegian Antarctic Expedition of 1927-8.[1] But Ferguson, during the Salvesen Expedition of 1913, passed close enough to Clarence Island to make a few observations (*op. cit. supra*, p. 36). He says: 'The north-east coast is a wall-like rampart, 500 ft. or more in height, of very regular and well-bedded rocks, light grey, dark grey, and drab coloured. The west coast shows light grey, finely banded rocks with a nearly vertical dip in places, and a broad band of brownish rock, evidently an intrusion, was seen at one place cutting through them.' This description agrees well with Holtedahl's and with photographic views of the north-western coast of Clarence Island published by Holtedahl (*op. cit.* pls. xxiii, xxiv).

As regards the rocks, Holtedahl collected a number of characteristic specimens from the scree at

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[1] O. Holtedahl, 'On the Geology and Physiography of Some Antarctic and Sub-Antarctic Islands', *Scientific Results of the Norwegian Antarctic Expeditions of* 1927-8 *and* 1928-9, *instituted and financed by Consul Lars Christensen*, No. 3, Norske Vidensk.-Akad., Oslo, 1929, 172 pp. (Clarence Island, pp. 47-8).

the foot of a precipitous mountain wall rising behind the beach where he landed, and from wave-rounded boulders. He gives the following brief particulars:

> The rocks are rather highly metamorphic, grey or greenish in colour, with a more or less distinct schistosity, rather fine-grained, most of them, however, showing a crystalline texture well already (*sic*) to the naked eye.
>
> A grey rock is, according to Broch, a fine-grained albite-epidote-biotite-schist, with quartz and hornblende, further muscovite, titanite, apatite. A chemical analysis shows an andesitic composition.[1]
>
> A greenish chlorite-schist has a basaltic composition. A grey rock, with hardly any schistosity and less fine-grained, is by Broch found to be mainly made up of albite, epidote, hornblende, biotite. It probably represents a highly altered basic igneous rock.
>
> These greenish or greyish rocks show a fairly distinct bedding that may be seen in pl. xxiii, fig. 3. The dip is there rather varying both as to inclination and direction. The main direction of the strike is probably south-west to north-east, parallel to the north-western coast. Such a strike is at any rate typical of the extreme western part of the island.

The strike of the rocks in Clarence Island is thus not very different from that in Elephant and Cornwallis Islands, and it is to be expected that the same or similar rock types will recur in Clarence Island. From the above brief description of the rocks it would appear that they are comparable in mineral composition and metamorphic grade with those described by Tilley from the southern point of Elephant Island.

In the preface to his memoir Holtedahl says that his rock specimens had been assigned to O. A. Broch for petrological investigation. Eventually, however, the work was taken over by T. F. W. Barth and P. Holmsen.[2]

In regard to Clarence Island, Barth and Holmsen give very brief descriptions of a 'common schistose greenstone' and a chlorite-schist, of which analyses are given. In their Table of Analyses (p. 60, *op. cit.*) these rocks are designated respectively as: biotite-epidote-actinolite-albite-schist, and chlorite-actinolite-clinozoisite-albite-schist. These analyses are discussed later (see Table 6, p. 87).

DREDGED STONES FROM SOUTH OF CLARENCE ISLAND

Among the Discovery II material submitted to me was a box containing numerous stones dredged on 23 February 1927 at St. 170 at a depth of 342 m. The exact position is long. 61° 25′ 30″ S., lat. 53° 46′ W. On Chart no. 6[3] a sounding of 342 m. is shown about 7 miles south-west of Cape Bowles, the southernmost point of Clarence Island, but this sounding is shown on the chart at lat. 54° 15′ W., the longitude being the same as that given above. The position of this sounding is about 30 miles east-south-east of the eastern coast of Elephant Island.

The question of the provenance of the stones is rather difficult. It depends on the prevalent direction of the marine currents near Clarence Island, both as affecting direct transport of the stones, and as influencing the drift of icebergs which may have carried the stones or some of them from Elephant Island, or even from more southern localities. It will be assumed that the majority of the stones came from Clarence Island, some from Elephant Island, and possibly a very few from the south.

PETROGRAPHY

The stones range in size from about 3 in. in greatest diameter down to half an inch. They are all covered with a thick growth of calcareous marine organisms. When this is chipped or dissolved off it can be seen that most of the stones consist of fine-grained grey and green schistose rocks, often profusely veined with quartz. Thirty-five of the stones were sectioned for petrographic examination. Four were found to be igneous rocks, three sedimentary, and twenty-eight metamorphic.

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[1] This is presumably the analysis of a 'schistose rock' quoted on p. 109 of Holtedahl's memoir.

[2] 'Rocks from the Antarctandes and the Southern Antilles', *Scient. Res. of the Norwegian Antarctic Expeditions*, 1927–28 *and* 1928–29, No. 18, Norske Vidensk.-Akad., Oslo, 1939, 64 pp. (Clarence Island, pp. 59–60).

[3] H. F. P. Herdman, 'Report on Soundings taken during the Discovery Investigations, 1926–32', *Discovery Reports*, VI, 1932.

IGNEOUS ROCKS

Porphyritic micro-diorite (*quartz-diorite-porphyry*). This is a fine-grained rock consisting of diversely arranged laths of plagioclase (oligoclase-andesine), with subordinate chlorite representing an original ferromagnesian mineral, probably hornblende, irregular grains of titano-magnetite, a little interstitial quartz, and an abundance of thin needles of apatite. The porphyritic constituents are few and consist solely of badly altered plagioclase (probably andesine). This rock resembles the quartz-diorite porphyries which are abundant in the South Shetlands, the Palmer Archipelago and Graham Land.

Porphyritic hornblende-micro-granite (*hornblende-quartz-porphyry*). This is an interesting and unusual rock with very numerous euhedral phenocrysts of feldspar, quartz, hornblende, biotite, and ilmenite, with apatite in well-formed crystals as an abundant accessory, embedded in a pale brown, glassy to crypto-crystalline ground-mass. The feldspars are much sericitized and consist of orthoclase and oligoclase (Ab_4An_1) in roughly equal proportions. Quartz occurs as large embayed crystals up to 0·5 cm. in greatest diameter, often with edges and corners rounded by corrosion. The hornblende forms prisms and plates of green to pale yellowish brown pleochroism, and is often partially or completely altered to chlorite of high D.R. The biotite is completely altered to a pale green chlorite of anomalous 'ultra-blue' polarization colour, with the disengagement of magnetite. Ilmenite altering to leucoxene occurs in large scattered crystals. The phenocrysts form more than half the rock.

Spherulitic quartz-porphyry. This rock contains a few small embayed phenocrysts of quartz, rather more abundant euhedral phenocrysts of very turbid orthoclase and a few of albite, in a micro-crystalline and spherulitic ground-mass. The spherulites are often perfect; they may be isolated in the ground-mass, but more often they are grouped around the phenocrysts. The only ferromagnesian minerals are a few small areas of chlorite with separated magnetite, and one or two large crystals of titano-magnetite.

Rhyolite. This rock consists mainly of a crypto-crystalline but obviously quartzose ground-mass, with numerous parallel streaks of micro-granitic material. The latter consists of quartz and turbid orthoclase intergrown with the production of a rough micrographic structure. A few small phenocrysts of oligoclase, orthoclase and quartz occur, but the only ferromagnesian constituents are represented by ragged patches of titano-magnetite, and a few flakes of chloritized biotite, which are associated with the streaks of micro-granite. This rock may be regarded as a rhyolite with flow structure. It may represent a lava, or perhaps more probably, a small dike.

These acid volcanic or dike rocks may have come from the extreme northern tip of Graham Land, where O. Nordenskjöld has described a similar series, mostly tuffs, at Flora Bay.[1] Also, at Hoffnungs Bay,[2] he found acid porphyries and porphyry tuffs, apparently concordant with folded and metamorphosed Jurassic sediments.

SEDIMENTARY ROCKS

Only three of the stones can be regarded as unmetamorphosed sediments. These are all greywackes, one of sand grade, and the other two of silt grade.

The coarser greywacke is grey-green in colour and quartzite-like in aspect. In thin section it is seen to consist mainly of very angular fragments of quartz and feldspars, with a little biotite (altered to chlorite and magnetite), pale pink garnet, and some epidote, sericite, and chlorite developed as secondary minerals. In addition to the mineral fragments there are numerous rock chips, including carbonaceous shale, chert, fine-grained quartzite, sericite-schist, and fragments of the ground-mass of trachytic and felsitic igneous rocks. Most of the quartz shows a marked undulose extinction

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[1] 'Untersuchungen aus dem westantarktischen Gebiete', *Bull. Geol. Inst. Upsala*, VI, 1900, p. 239.

[2] 'Antarctis', *Handbuch der Regionalen Geologie*, Bd. VIII, Abt. 6, 1913, p. 9.

indicative of strain. The feldspars include orthoclase and albite (always turbid), and clear fresh andesine ($Ab_{70}An_{30}$). The rock is traversed by thin veins of secondary quartz, epidote and calcite.

The remaining two rocks have the same composition as that above-described, but the grain-size is coarse silty. They contain a greater abundance of biotite, chlorite and garnet, but rock chips are not so much in evidence, probably because of the finer grain. A few crystals of apatite occur in these rocks, and in one of them carbonaceous streaks delineate the bedding planes. The same slide shows a plane of shearing along which coarse sericite and chlorite have been developed.

These rocks are probably due to the rapid waste of a terrain of miscellaneous rocks, including acid and intermediate volcanic types, shales, cherts, quartzites, and schists. The abundance of quartz with undulose extinction points to the presence of gneisses, or, more likely, of a quartz-porphyry formation which has undergone extreme mechanical deformation, within the area of erosion. A mylonized porphyry formation of this character covers great areas in Patagonia and Tierra del Fuego, and has also been found in West Antarctica as far to the south as Adelaide Island (see this Memoir, p. 74).

Greywackes and greywacke-siltstones of ancient aspect are common in Tierra del Fuego in formations of Late Palaeozoic and Early Mesozoic ages;[1] and O. Nordenskjöld (*op. cit. supra*, p. 238) has described non-schistose slates and greywackes underlying fossiliferous sediments of Jurassic age in Hope Bay at the northern end of Graham Land. He also asserts the abundance of porphyries and porphyry tuffs in the same area. It is therefore possible that the above-described stones came from this region; but, from the identity in composition of the stones, and the fact that they were associated together in the same dredging, it is considered to be at least as likely that they were derived from the nearest land, i.e. Clarence Island.

METAMORPHIC ROCKS

Twenty-eight, or four-fifths, of the dredged stones belong to metamorphic types. The great majority of these are due to the dynamic metamorphism of sedimentary rocks resembling the Scottish 'faikes', alternate laminae of carbonaceous shales and quartzose siltstone or sandstone. These rocks have been intricately folded, sheared, crushed, and converted into carbonaceous sericite-phyllites alternating with quartzose phyllite and quartz-sericite-schist. Some of the rocks contained a significant amount of calcareous cement which has been recrystallized as calcite. This mineral is occasionally so abundant that the rocks have to be recognized as calc-sericite-schists.

Thin flakes of sericite are profusely developed in both the siliceous and argillaceous laminae. Calcite and chlorite are formed mostly in the coarser quartzose bands. The chlorite, developed from ferromagnesian impurities in the original sediments, is usually a pale green variety with 'ultra-blue' polarization colours. It is often vermicular and then almost isotropic. Epidote is sparingly developed in the earlier stages of metamorphism, and generally in the slaty laminae.

Some of the rocks are minutely folded and puckered, even within the limits of a thin section (Fig. 11), and the thicker laminae of phyllite acquire a strain-slip cleavage parallel to the axes of folds in the coarser quartzose layers. Others are sheared and smashed into small fragments with the production of crush-breccias. These crush-breccias are often rolled out and a kind of flaser structure is developed, consisting of lenticular fragments of the brittle quartzose layers around which the phyllite laminae have been forced to wind. The quartz grains grow during this process and ultimately form a coarse mosaic. Similarly the size and amount of the sericite flakes increase with the degree of internal movement. These rocks develop into well-crystallized quartz-sericite-schists at the climax of the metamorphic reconstitution.

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[1] E. H. Kranck, 'Geological Investigations in the Cordillera of Tierra del Fuego', *Acta Geographica*, IV, no. 2, Helsinki, 1932, pp. 231.

A few of the rocks, which must originally have been rich in calcareous and argillaceous matter, contain abundant calcite and epidote. The latter mineral is no doubt produced by the well-known reaction between calcareous and argillaceous matter during metamorphism. Quartz-calcite-epidote-schists are thus formed. As the degree of metamorphism increases, epidote becomes the dominant mineral with the dwindling or disappearance of calcite and sericite. The final product of this change is a quartzose epidosite. All of these rocks are intersected by a profusion of secondary quartz veins.

A rock which may belong to the above series is a saccharoidal metamorphic quartzite which carries scattered and irregularly bounded patches of coarse sericitic material. This may perhaps be interpreted as representing one of the thicker beds of sandstone that may have contained clay galls.

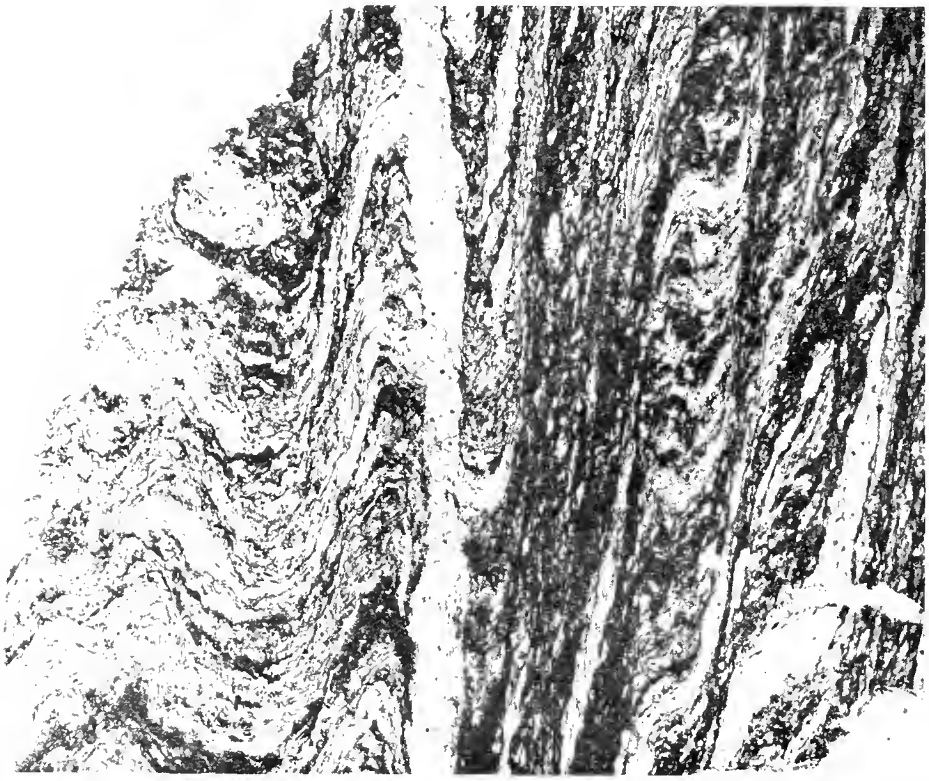

Fig. 11. Section of phyllite, showing folding.

Another specimen shows many points of resemblance to the above-described series, especially in the abundance of argillaceous material and the presence of calcite, epidote and sericite. It differs, however, in that some of the folia are rich in large, angular fragments of alkali-feldspars, including orthoclase and albite, which are still comparatively fresh. This may perhaps be best interpreted as a sheared rhyolitic tuff, intermingled with normal sedimentary material.

The remaining three stones of the metamorphic group are quartz-epidote-amphibole-schists which have probably been derived from basic igneous rocks or their tuffs. One is a quartz-albite-tremolite-epidote-schist; the other two are calcite-quartz-glaucophane-epidote-schists.

The first is a fine-grained, apparently bedded rock with a schistosity coinciding with the bedding planes. It consists mainly of a mixture of minute grains of epidote with microlites of albite, and prisms of colourless to pale green tremolite which have a tendency to lie athwart the planes of schistosity. This material carries large and small folia consisting of quartz and albite, both enclosing innumerable needles and thin plates of tremolite. The albite often forms large, simply twinned, blasto-porphyritic crystals developed in a mosaic of quartz and small albites. The largest and coarsest of these folia has a distinct resemblance to an aplite vein. This rock is somewhat difficult to interpret, but the conjecture may be hazarded that it is derived from a rock of the spilitic suite, perhaps a tuff. It has a considerable resemblance to the slightly metamorphosed spilitic lavas of North Glen Sannox (Arran).[1]

Of the glaucophane rocks, one is a quartz-albite-epidote-chlorite-glaucophane-greenstone devoid of schistosity; the other is schistose and carries abundant calcite in addition to the above-mentioned minerals. In both rocks quartz, albite, and calcite, form a coarse, even-grained mosaic, within and between the grains of which the coloured minerals are developed. In the greenstone the latter are interspersed among the colourless minerals, and are non-schistose; in the schist the coloured minerals occur as streams winding through the colourless matrix, or they form folia alternating with broad bands consisting of quartz, albite, and calcite.

The chlorite is of the deep green penninite variety with low birefringence and anomalous 'ultra-blue' interference colours; it is associated with colourless to pale green muscovite. The epidote is of the normal yellowish green variety and is associated with much leucoxenic material. Glaucophane is abundant in both rocks. It has a striking pleochroism as follows:

X = pale yellowish green,
Y = violet,
Z = azure blue.

In the schist it appears to be altering to a greenish blue soda-amphibole devoid of the violet pleochroism, and with a rather high extinction angle (up to 20°). This may be the 'abnormal glaucophane' rich in a lime molecule, which is mentioned by Winchell.[2]

These rocks are probably due to the recrystallization of igneous rocks of the spilitic series under dynamothermal metamorphism. The abundance of quartz and calcite, with a little muscovite, may indicate that the original rocks were tuffaceous and mingled with normal sedimentary material. Very similar rocks are mentioned by Harker as forming the *prasinite* type of the Alps.[3] Kranck[4] has described a glaucophane-garnet-schist from Bahia Plüschow in Tierra del Fuego. Its mineral composition is: garnet, glaucophane, quartz, sericite, biotite, chlorite, calcite, apatite, magnetite. This rock is interbedded with garnetiferous quartz-schists and belongs to the Yahgan or Mt Buckland formation. Kranck regards it as due to the metamorphism of a carbonate-rich sandstone [greywacke?].

THE GIBBS ISLAND GROUP

This is a group of three small islands, O'Brien Island, Aspland Island and Gibbs Island (with Narrow Island joined to it), lying about 20 miles south-south-west of Cape Lookout on Elephant Island. Practically nothing was known of the geology of these islands until 1937 when a landing was made on Gibbs Island by a party from the 'Discovery II'. D. Ferguson, however (*op. cit. supra*, p. 35), was caught in a terrific gale and had to shelter for some time under the lee of Gibbs Island. He says: 'The steamer was sufficiently near to show that the rocks were mainly stratified sediments. The rocks on the west [south?] side of Gibbs Island are dark grey and banded, and dip about 40° W. A higher horizon is represented by some uniformly and well bedded greyish-white rocks which dip about 18° W. They extend for about ¼ mile, and look soft and friable in places. Aspland Island, 5 or 6 miles west of Gibbs Island, is evidently formed of the same regularly bedded rocks, but they dip east.'

A landing on Gibbs Island and Narrow Island was made by J. W. S. Marr on 2 November 1937, and the following facts concerning the geology of the island have been culled from his report (unpublished MS.).

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[1] G. W. Tyrrell, 'The Geology of Arran', *Mem. Geol. Surv., Scotland*, 1928, p. 26.

[2] A. N. Winchell, *Elements of Optical Mineralogy*, Part II, 3rd ed., 1933, p. 259.

[3] A. Harker, *Metamorphism*, 1932, p. 291.

[4] E. H. Kranck, *op. cit. supra*, pp. 52–4.

Gibbs Island is high and steep, rising abruptly out of the sea which is deep close inshore. The coast almost wholly consists of sheer and inaccessible cliffs reaching a maximum elevation of about 1000 ft. These rock walls are remarkably ice-free, and only a thin mantle of highland ice crowns the rising ground above them. Gibbs Island is joined to Narrow Island by a low shingle and boulder spit, 50–80 yards long, which is probably awash at high tide. In its general features Narrow Island is similar to Gibbs Island.

The south coast of Gibbs Island is largely composed of a fine-grained schistose rock penetrated by occasional quartz veins. The planes of schistosity are conspicuous from the sea and dip south-west at an angle of about 30°. Specimens of the rock were obtained from an outcrop near sea level on the south coast near the landing place and from another outcrop about 150 ft. higher. The steep screes which descend to the sea are almost exclusively composed of slabs of the grey phyllite. Above the screes, starting at 500 ft., is a vertical rock face reaching a height not far short of 1000 ft. As this cliff has obviously provided the scree material it is undoubtedly composed of the same phyllite. About 100 ft. above the landing beach [in another direction?] is an outcrop of a massive, dark olive-green rock [serpentine] which has given rise to boulders on the shore.

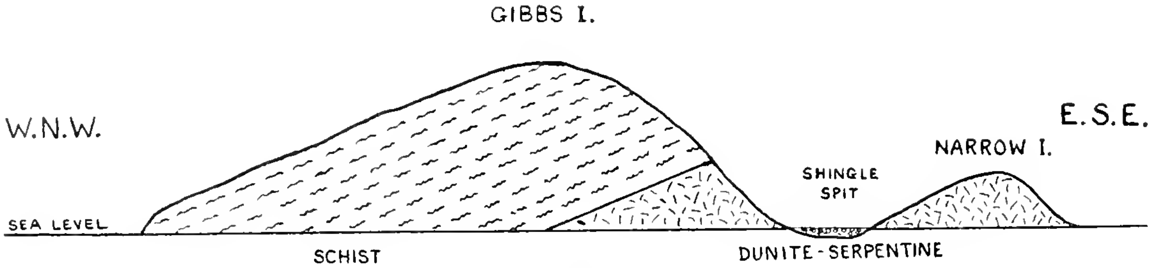

Fig. 12.

Narrow Island, on its south side, appears from the sea to be composed of a massive rock of reddish brown hue, with no sign of the schistosity which characterizes the southern face of Gibbs Island. A landing was made on the south coast near the connecting spit, and a specimen was obtained from the cliff face a few feet above sea level. This rock is the dunite-serpentine described below.

From the data given above a tentative sketch section may be drawn showing the probable geological structure of Gibbs Island (Fig. 12). The view is here taken that the serpentine has been intruded parallel to the foliation planes of the schist.

PETROGRAPHY

The rocks of Gibbs and Narrow Islands comprise two sharply contrasted types, namely, schists and serpentine.

Schists. Five of the specimens were sliced for microscopic examination. They can be described in general terms as chlorite-sericite-albite-schists containing, in addition, quartz, calcite, and minerals of the epidote group (clinozoisite, zoisite) in some abundance. Small garnets and a mineral of the chloritoid group are found in one specimen, and the latter mineral also occurs in another rock. In hand specimens the rocks show a fine, parallel schistosity yielding flat cleavage surfaces varying in colour from light silvery grey to lead grey.

In thin section the rock containing garnet and chloritoid shows a thin foliation with somewhat larger grains of quartz and feldspar taking part in a minute flaser structure. The garnets are small and sparsely distributed; chloritoid is rather more abundant, and occurs as pleochroic grey-blue prisms with good cross fracture.

Another rock consists of a mosaic of small grains of quartz through which wind thin folia of interwoven flakes of sericite, and folia made up of large crystals of green pleochroic chlorite with 'ultra-blue' polarization colours. In some of the intervening folia of quartz are remarkable 'trails' consisting of small euhedral crystals of zoisite, strung out as a line of separate crystals, or occurring in small clots. Both the slide and hand specimen of this rock show that it has been permeated by vein quartz which has separated and isolated the individual folia.

A third type is rich in epidote. It shows alternating folia consisting (1) largely of quartz with subordinate albite and calcite, but carrying films or thin folia of chlorite and epidote, and scattered crystals of the same two minerals, and (2) mainly of chlorite flakes interwoven with epidote grains. Sericite may form a notable constituent of these folia, but quartz only occurs as scattered fragments.

The most feldspathic type is a comparatively coarse schist consisting of more or less rounded grains of albite, intermingled with smaller grains of quartz and patches of calcite, forming a mosaic through which wind streams of flakes of chlorite and sericite, together with grains of epidote and zoisite, and interwoven folia of these minerals. The albite is fresh and water-clear and is mostly untwinned, but a few crystals show simple twinning or the more usual albite twinning. Many of the albites contain curving lines of inclusions of the above minerals, suggesting their growth by accretion during shearing as in the well-known case of 'snowball' garnets. This rock closely resembles the albite schists of the south-western Highlands of Scotland.[1]

As a whole the series of schists from Gibbs Island closely resembles those of Elephant Island and Clarence Island, especially those of Minstrel Bay, but they are coarser, somewhat more highly metamorphosed, and do not possess the abundant carbonaceous matter of those rocks.

Dunite-serpentine. The least altered rock and the only one that contains unaltered olivine, is the specimen which was collected from the south coast of Narrow Island. All of the serpentine rocks collected show signs of intense shearing. They are, in fact, serpentine-schists of apple-green and malachite-green colours and ornamental appearance. Some of the specimens show opaque patches, streaks and veins of a black metallic mineral which turns out to be magnetite.

The Narrow Island rock must have consisted almost entirely of olivine crystals, but it is now made up of olivine fragments in a mesh of serpentine. The only other mineral is magnetite, a little of which may be primary but, for the main part, is undoubtedly of secondary origin. The olivine is a highly magnesian chrysolite with $2V = 90^\circ$ and positive sign, and therefore with a FeO content of about 13 per cent. About half of it has been transformed to serpentine or allied substances. The alteration proceeds as usual along the fissures and from the peripheries of the crystals. The first effect of alteration is to produce a pale brownish yellow uncleaved mineral which is of very low birefringence or sensibly isotropic (delessite?), shot through with colourless fibres of positive elongation which may be chrysotile. These areas of delessite(?) and chrysotile roughly outline the original hexagonal forms of the olivine crystals, and enmesh fragments of them. The next stage of alteration produces colourless antigorite in irregular sheaves of platy crystals with negative elongation, which can be seen to be growing at the expense of the areas of delessite(?) and chrysotile, with the liberation of iron oxides in the form of ragged grains of magnetite.

In the remaining specimens of serpentine, all from the south coast of Gibbs Island, the alteration is completed. Not a trace of olivine is left, nor of delessite(?) and chrysotile. The whole rock consists of antigorite in closely woven felts of plates and prisms, with irregular ragged strings of magnetite which have sometimes segregated into definite secondary veins about 1 mm. thick. The shearing to which the rocks have been subjected has caused the reformation of the antigorite along the major lines of movement, often with a superposed cross-lamellation. With a more severe crushing stress,

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[1] A. Harker, *Metamorphism*, 1932, p. 213. The rock figured on this page (fig. 95 A) strongly recalls the microscopic appearance of the Gibbs Island rock.

however, the crystals have been ground to powder, and wind in streaks around larger fragments which have assumed a pseudo-spherulitic form.

The dunite-serpentine of Narrow Island has been analysed by F. Herdsman, A.R.S.M., with the results shown in Table 5, col. 1. For comparison an analysis of dunite-serpentine from Cornwall is given. The resemblance between the two analyses is obviously very close. The calculated norms of both rocks give about 50 per cent olivine and 40 per cent enstatite. While the Cornish rock is stated to contain some enstatite and tremolite (*op. cit.* p. 64) not a trace of these minerals can be found in the dunite-serpentine of Narrow Island. It may perhaps be surmised that in the alteration to serpentine there has been some differential abstraction of magnesia and iron oxide relative to silica. This appears to be the first record of dunite and serpentine in the West Antarctic region.

Table 5

	1	A
SiO_2	41·85	40·12
Al_2O_3	1·37	0·98
Fe_2O_3	2·62	6·52
FeO	2·16	1·21
MgO	39·44	35·78
CaO	tr.	0·12
Na_2O	tr.	0·24
K_2O	0·13	0·08
H_2O^+	11·03	12·17
H_2O^-	0·45	1·69
CO_2	nil	0·15
TiO_2	tr.	tr.
P_2O_5	0·22	0·10
MnO	tr.	0·52
(Ni, Co)O	0·24	0·15
Cr_2O_3	0·19	0·28
V_2O_3	—	tr.
BaO	—	nil
FeS_2	—	0·01
	99·70	100·12

1. Dunite-serpentine, Narrow Island, West Antarctica. Anal. F. Herdsman.

A. Dunite-serpentine, Predannack, The Lizard, Cornwall. Anal. E. G. Radley. Quoted from J. S. Flett and J. B. Hill, 'The Geology of the Lizard and Meneage, *Mem. Geol. Surv., England and Wales*, Expl. of Sh. 359, 1912, p. 79.

CHEMICAL COMPOSITION AND ORIGIN OF THE METAMORPHIC ROCKS OF THE ELEPHANT AND CLARENCE GROUP

No new analyses have been made of the rocks described above, since none of them has been collected *in situ* or located with exactitude except a few from Gibbs Island. Four analyses, however, have been published, two each from Elephant and Clarence Islands, and these are collected in Table 6, together with a few comparable analyses from Tierra del Fuego, South Georgia, etc.

Prof. Tilley regards the rocks of Lookout Harbour, Elephant Island, as a 'graded series of related sediments ranging from limestones to impure types giving the amphibolites and garnet-hornblende-schists rich in albite'. The amphibolites are closely associated, and even interbedded, with limestone bands. Tilley surmises that the original sediments were somewhat abnormal inasmuch as abundant albite was present. But there is one type of sediment, quite abundant and by no means abnormal, which is often rich in soda and often rich in albite, namely, the impure sandstones known as greywacke. The most typical greywackes are constituents of ancient fold-mountain ranges wherein they are often associated with mudstones, slates, greenstones, ophiolites, and especially with igneous rocks

Table 6

	1	A	B	2	C	D	3	4	E
SiO_2	47·37	48·63	51·56	57·66	53·56	53·75	45·10	71·80	73·04
Al_2O_3	16·46	14·85	17·54	16·30	19·32	18·60	14·76	11·87	10·17
Fe_2O_3	1·92	1·91	1·80	3·46	1·06	2·04	4·50	2·21	0·56
FeO	7·41	9·47	8·28	2·46	7·44	6·97	9·87	2·30	4·15
MgO	8·64	7·93	5·23	3·95	3·43	2·30	5·95	1·94	1·43
CaO	10·19	7·20	11·42	6·01	5·21	6·98	11·59	3·02	1·49
Na_2O	2·74	2·98	2·18	4·39	3·86	4·06	2·55	3·27	3·56
K_2O	0·06	0·30	0·33	2·68	1·96	1·32	0·47	1·02	1·37
H_2O^+	3·38	4·09	0·34	0·98	2·29	0·76	0·26	1·29	2·36
H_2O^-	0·10	0·21	0·22	0·10	0·06	0·07	0·10	0·48	
CO_2	0·21	0·18	nil	0·12	0·20	0·49	1·38	nil	0·84
TiO_2	1·20	2·34	0·56	0·85	1·02	2·83	2·51	tr.	0·15
P_2O_5	0·14	0·01	tr.	0·55	0·22	tr.	0·21	0·16	0·23
MnO	0·15	0·12	0·36	0·11	0·12	0·18	0·26	0·45	0·18
(Ni, Co)O	—	—	—	—	—	—	tr.	nil	—
BaO	—	—	—	0·08	0·06	—	—	—	—
S	0·02	0·21	—	0·19	0·07	—	0·23	0·08	0·10
SO_3	—	—	—	—	—	—	0·20	—	—
Cl	nil	—	—	0·02	tr.	—	—	—	—
F	nil	—	—	nil	tr.	—	—	—	—
C	—	—	—	—	—	—	—	—	0·17
	99·99	100·43	99·82	99·91	99·88	100·35	99·94	99·89	99·80

1. Chlorite-actinolite-clinozoisite-albite-schist ('very schistose'), Clarence Island. Anal. E. Klüver. Quoted from Barth and Holmsen, *op. cit. supra*, p. 60. This rock is briefly described as containing chlorite, actinolitic hornblende, clinozoisite, and albite (An_0). Calcite and quartz occurred in fissures. It is stated that the latter minerals were removed before the analysis was made (Barth and Holmsen, p. 59).

A. Ophiolitic greenstone, north of Monte Olivia, Ushuaia, Tierra del Fuego. Anal. L. Lokka. Quoted from E. H. Kranck, *op. cit. supra*, p. 111. This rock is stated to be an 'effusive' associated with slates and phyllites of the Yahgan (or Mt. Buckland) Formation (probably Lower Mesozoic). It is sheared and mylonized in places. The freshest material shows oligoclase (An_{25}) and augite altering to hornblende. Chlorite, epidote, actinolite, sphene altering to leucoxene, quartz, and albite, occur in the highly sheared varieties. In its geological associations and petrography this rock is obviously similar to no. 1.

B. Tremolitic greenstone, stones dredged near the Shag Rocks, about 130 miles west of South Georgia. New analysis by F. Herdsman. See this work, p. 91.

2. Biotite-epidote-actinolite-albite-schist ('not very schistose'), Clarence Island. Anal. E. Klüver. Quoted from Barth and Holmsen, *op. cit. supra*, p. 60. This rock is stated to be a 'common schistose greenstone, the constituent minerals of which are: green biotite, actinolitic hornblende, ferriferous epidote, and albite (An_0). [From the analysis it is tolerably certain that quartz should be added to this list.] The summation of this analysis is incorrectly given as 99·82 in Barth and Holmsen, but is correctly stated in Holtedahl, *op. cit. supra*, p. 109.

C. Sheared tuff, from moraine, Virik Harbour, South Georgia. Anal. E. Klüver. Quoted from Barth and Holmsen, *op. cit. supra*, p. 50. These tuffs contain fragments of keratophyres, trachyandesites, and spilites (see G. W. Tyrrell, 'Petrography and Geology of South Georgia, '*Quest' Report* (*Brit. Mus. Nat. Hist.*), 1930, pp. 35–7). This analysis compares well with that of the Clarence Island rock (no. 2), with the exception of higher FeO and lower SiO_2. Holtedahl (*op. cit. supra*, p. 109) makes the same comparison. The summation of this analysis is incorrectly given as 99·84 in Barth and Holmsen.

D. Mylonitic diorite, Valle Desillusion, north of Lapataia, Beagle Canal, Tierra del Fuego. Anal. L. Lokka. Quoted from E. H. Kranck, *op. cit. supra*, p. 99. This rock is stated (Kranck, p. 95) to be a highly mylonized gneissic rock interfolded with the sedimentary schists of the Yahgan (Mt. Buckland) Formation. It shows films of chlorite and mica winding between crushed lenses of feldspars (microcline and plagioclase) and abundant quartz. Zoisite has been formed from the plagioclase. The analysis compares well with that of the Clarence Island rock except for much higher FeO and lower K_2O.

3. Para-amphibolite, Lookout Harbour, Elephant Island. Anal. Herdsman. Quoted from C. E. Tilley, *op. cit. supra*, p. 61.

4. Garnet-albite-schist, Lookout Harbour, Elephant Island. Anal. Herdsman. Quoted from Tilley, *op. cit. supra*, p. 60.

E. Greywacke (Kulm), Steinbach, Frankenwald, Germany. Quoted from R. Eigenfeld, 'Die Kulmconglomerate von Teuschnitz im Frankenwalde,' *Abh. Math.-Phys. Kl. Sächs. Akad. Wiss.* XLII, no. 1, 1933, p. 58.

of the spilitic suite. These *geosynclinal* greywackes are rich in fragments of intermediate, basic and ultrabasic igneous rocks and their minerals, especially spilites and their associates.[1]

Spilitic lavas are of submarine or at least subaqueous origin. The greywackes formed of their debris may be regarded as due to disintegration by submarine eruptions aided to some extent by subaqueous gliding (Bailey),[2] which distribute an enormous amount of 'greenstone' debris, mingled with sand and mud, far and wide over the oceanic regions affected. In its descent through the water this material would become sorted with regard to grain size and would form graded sediments ranging from greywacke to mudstone. This view would explain the frequent passage of greywackes to siltstones and mudstones on the one hand, and into tuffs on the other. Furthermore, limy material lying on the sea floor, and also the radiolarian cherts and impure limestones which are often associated with spilitic lavas, would be incorporated in these sediments. Moreover, spilitic lavas and their tuffs are very frequently saturated with carbonate of lime, which would reappear as calcite in the greywackes resulting from their disintegration.

Towards the deeper parts of the oceans these sediments would merge gradually into the blue carbonaceous and ferruginous muds appropriate to this locus; and towards the coasts they would pass into the terrigenous sands and muds of the continental shelves.

The greenstone-greywacke-mudstone association is generally formed during the geosynclinal stage of the orogenic cycle, and is therefore commonly affected by the low-grade metamorphism which ensues when the later orogenic movements take place. Slates, phyllites, and quartz-sericite-schists are thus formed from the mudstones and siltstones; fine-grained quartzites and quartz-schists from cherts and other siliceous rocks; schistose grits, quartz-chlorite-albite-schists, and greenstones such as those found in the 'Green Beds' of the Scottish Highlands, from the greywackes and greywacke-tuffs; epidiorites, greenstones, chlorite-schists, hornblende-schists, amphibolites, etc., with epidote, zoisite, garnet, and other accessory minerals, from the basic igneous rocks and their tuffs. Glaucophane-bearing schists may be formed from the soda-rich varieties of these rocks, or from greywackes composed of their debris.

It is precisely an assemblage of this character which is encountered in the Elephant and Clarence Group and the South Orkneys. South Georgia, too, is composed of greywackes and greywacke-tuffs with slates and phyllites, and an occurrence of spilitic rocks is found at the eastern end of the island. Such an assemblage may also form the basement of Graham Land and the adjacent archipelagos. Above all, it is represented in Tierra del Fuego by the rocks of the Yahgan or Mt. Buckland formations, and by some of the Central Schists of that region. Since radiolarian cherts are abundantly developed here, it is probable that the whole assemblage belongs to the geosynclinal greenstone-greywacke-mudstone association discussed above. It is difficult to read Kranck's descriptions of the petrography of these rocks (*op. cit. supra*) and not to recognize that in West Antarctica we are dealing with exactly similar groups of sedimentary and metamorphic rocks. The bearing of these considerations in favour of the theory of the tectonic connexion between South America and West Antarctica put forward by H. Arctowski, O. Nordenskjöld, and E. Suess, is obvious.[3]

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[1] There are, of course, types of greywacke due to the waste of areas of miscellaneous rocks, including slates, basic igneous rocks, etc. These may be styled *continental* greywackes, and are strictly equivalent to arkoses, which are derived from the waste of a granitic or gneissic terrain.

[2] G. W. Tyrrell, 'Greenstones and Greywackes', *C.R. Réunion Internat. pour l'étude du Précambrien et des vieilles chaînes*, Finland, 1931, pp. 24–6. E. B. Bailey, 'New Light on Sedimentation and Tectonics', *Geol. Mag.* LXVII, 1930, pp. 77–92. The writer does not accept Bailey's view that greywackes are merely 'muddy sandstones'.

[3] For recent discussions of this problem see G. W. Tyrrell, 'Petrography and Geology of South Georgia', '*Quest' Expedition Report* (*Brit. Mus. Nat. Hist.*), 1930, pp. 51–4; and H. F. P. Herdman, 'Report on Soundings taken during the Discovery Investigations, 1926–32', *Discovery Reports*, VI, 1932, pp. 214–19.

PART IV. PETROGRAPHY OF STONES DREDGED FROM THE VICINITY OF THE SHAG ROCKS

INTRODUCTION

One of the most remarkable geological features of the West Antarctic region is the existence of an eastwardly-directed loop of submarine ridges and islands which connects Staten Island in Tierra del Fuego, through the Burdwood Bank, Shag Rocks, South Georgia, Clerke Rocks, South Sandwich Islands, the South Orkneys, and the Elephant and Clarence Group, with the Graham Land peninsula and its adjacent archipelagos. It represents an extension of Circum-Pacific orogenic structures for more than 1000 miles into the heart of the alien geological region of the South Atlantic. This loop or arc has been called the Southern Antilles on the basis of a supposed analogy with the Antilles connecting North and South America; but a better term is the *Scotia Arc*, coined by J. M. Wordie, since the loop surrounds the Scotia Sea. The geological constitution of the Scotia Arc is consistent with the view, put forward by E. Suess and others, that it represents an orogenic tectonic connexion between South America and Graham Land.[1]

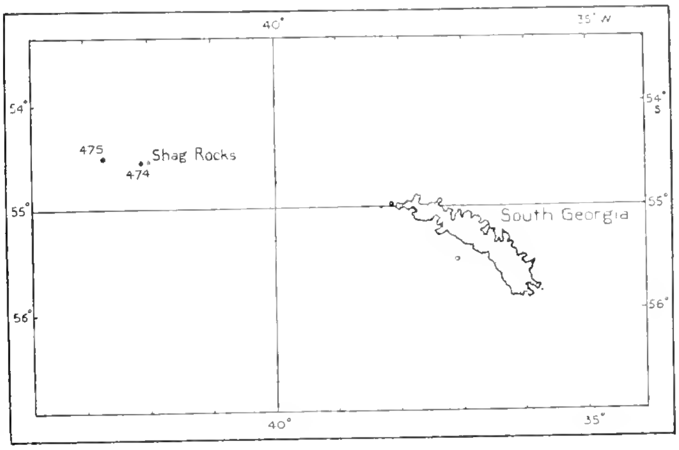

Fig. 13.

Something is known of the geology and petrography of all the connecting links of the Scotia Arc with the exception of the Shag Rocks. It is fortunate therefore, that two Discovery dredgings have been made in the vicinity of the Shag Rocks (see map, Fig. 13), which have provided sufficient material to enable us to assess the geological character of the Scotia Arc in this hitherto unknown region. These dredgings were made on 12 November 1930 by the 'Discovery II' at Sts. 474 and 475. The exact positions and depths are as follows:

St. 474. One mile west of the Shag Rocks. Depth 199 m.
St. 475. Long. 53° $30\frac{1}{4}$ S., lat. 42° $44\frac{1}{2}$ W. (about 25 miles west of the Shag Rocks). Depth 748 m.

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Fourteen stones came from St. 474 and five from St. 475. Of these nineteen stones, fifteen are practically identical and consist of tremolite-epidote-greenstone or greenstone-schist, one is a feldspathic quartzite, and three are quartz-vein rocks. The four last-named stones all came from St. 474, nearest to the Shag Rocks. The overwhelming preponderance of the greenstones in this collection makes it tolerably certain that this rock constitutes the Shag Rocks themselves and the submarine ridge on which they stand to at least 25 miles to the west.

The stones range in size from 4 in. to 1 in. in greatest diameter. Fifteen of them, as above stated, are 'greenstones'—dense, compact rocks of grey-green colour, showing an ill-developed cleavage along which they tend to split. Only two are definitely slaty or phyllitic in aspect. The quartzite is a fine-grained rock of a pale buff tint, and obviously contains much feldspar. The quartz-vein rocks are white and coarse-grained.

[1] Recent summaries of the evidence have been given by O. Holtedahl, 'On the Geology and Physiography of Some Antarctic and Sub-Antarctic Islands', *Scientific Results of the Norwegian Antarctic Expeditions 1927–8 and 1928–9, instituted and financed by Consul Lars Christensen*, No. 3, Norske Vidensk.-Akad., Oslo, 1929, pp. 104–18. G. W. Tyrrell, 'Petrography and Geology of South Georgia', '*Quest' Exped. Report* (*Brit. Mus. Nat. Hist.*), 1930, pp. 51–4. H. F. P. Herdman, 'Report on Soundings taken during the Discovery Investigations, 1926–32', *Discovery Reports*, VI, 1932, pp. 214–19.

Tremolite-epidote-greenstone. The principal minerals, as disclosed by thin sections, are tremolite, clinozoisite-epidote, chlorite, quartz, and albite. They are arranged in bands or elongated folia parallel to an ill-defined slaty cleavage which, in two or three of the sections, develops into a phyllitic or schistose structure. The cleavage planes are frilled and puckered by an imperfect strain-slip. The bands consist of one or two of the above minerals to the almost complete exclusion of the others. Folia consisting mainly of tremolite and clinozoisite or epidote are preponderant.

The tremolite occurs as colourless to pale green fibres, needles, prisms and plates, often arranged in parallel position or with a slightly divergent, sheaf-like structure. It has a good cross-fracture and longitudinal cleavage, although the typical prismatic amphibole cleavage is rarely seen. The extinction is at 10–20° to the cleavage direction (*c*). Its elongation is positive in sign, distinguishing it from the colourless variety of pargasite (edenite). Both epidote and clinozoisite are present. Epidote is the most frequent associate of the tremolite. It is of yellowish brown colour, and has usually undergone considerable alteration converting it into a greyish cloudy material (leucoxene?). This material forms ragged areas or, in the more highly cleaved types, it is drawn out into streaks and lines. It is possible that some of this material may represent altered sphene. Colourless clinozoisite occurs mainly as well-shaped crystals associated with quartz and albite in lenticles which may be partly of secondary origin.

Chlorite of the pale green variety with ultra-blue polarization occurs in irregular pods or stout lenticles. It is not abundant and, in a few places, appears to be growing at the expense of tremolite and epidote. Quartz, always with undulose extinction, is abundant in some lenticles and bands, and is associated with a little untwinned or simply twinned albite. Finally, in a few of the less altered rocks, very slender microlites of plagioclase (oligoclase?) can be detected. Discussion of the original character of this somewhat unusual greenstone is deferred to the section dealing with its chemical composition (p. 91).

Quartzite. This is a hard, yellowish, well-cemented sandstone or semi-quartzite. In thin section it is found to consist mainly of quartz and feldspars (plus alteration products) in roughly equal proportions. All the grains are angular and fit together like the stones in macadam. Only a few of the quartz grains show undulose extinction. The feldspar is easily distinguished by its turbid appearance. It includes soda-orthoclase and albite in about equal proportions. Many of the grains are comparatively fresh despite their turbidity, but others are completely altered to sericite and crystalline kaolinite. These alteration products have insinuated themselves into fissures in the quartz grains and between the grains, thus acting as a cement which has filled all open spaces. In addition to quartz and feldspar there are a few small grains of epidote, sphene, and iron ores, and rather more abundant fragments of what appears to be the ground-mass of dense acid igneous rocks like felsite or rhyolite. In fact, the mineral composition of the rock suggests that it may have been derived from the waste of rocks like the quartz-feldspar-porphyries which constitute the major part of a great Porphyry Formation in Patagonia and Tierra del Fuego, and are also found in parts of West Antarctica (see this Memoir, p. 75). The rock may thus be described as *quartzitic arkose*.

Quartz-vein rocks. These are all mainly composed of white quartz with films of a chloritic mineral. In thin section one of them shows quartz, albite, chlorite, and a little calcite, all intensely sheared and crushed. The quartz has marked undulose extinction and in the albite the twinning lamellae are bent and twisted. The chlorite is greyish green, and shows the common ultra-blue polarization; it is occasionally quite isotropic.

A second rock consists of intensely sheared and sliced quartz with some large crystals of greenish brown epidote. While clearly later than the quartz, the epidote crystals have also been bent and sliced by a movement in a different direction to that which first affected the quartz. The resulting fissures have been healed by the infiltration of silica. No albite or chlorite occurs in this rock.

A third quartz-vein rock consists of sheared quartz with films and folia of almost colourless, isotropic chlorite.

There is no evidence of the nature of the rocks penetrated by these veins. While there appears to be secondary quartz in the greenstones, there are no sharply defined veins. However, from their mineral composition and associations, it is likely that the quartz veins cut rocks of metamorphic type.

CHEMICAL COMPOSITION OF THE GREENSTONE

A composite sample from three of the least altered greenstones was analysed with the result shown in Table 7, col. 1. This analysis has a characteristically basaltic pattern with its comparatively high lime and alumina which, in the rock itself, is accounted for by the abundance of epidote and tremolite, and in comparable basalts, by richness in lime-plagioclase. The analysis is, for example, much like that of the Porphyritic Central Basalt type of Mull (Table 7, col. A), and like the basalt of the South Shetland Islands (Table 7, col. B). The latter, however, has a much higher *k* ratio than the Shag Rocks greenstone.

Table 7

	1	A	B	C
SiO_2	51·56	48·51	48·26	47·37
Al_2O_3	17·54	19·44	17·42	16·46
Fe_2O_3	1·80	5·66	3·36	1·92
FeO	8·28	4·00	5·61	7·41
MgO	5·23	5·12	8·83	8·64
CaO	11·42	12·03	11·56	10·19
Na_2O	2·18	2·53	2·44	2·74
K_2O	0·33	0·25	0·89	0·06
H_2O^+	0·34	0·48	0·24	3·38
H_2O^-	0·22	0·04	0·16	0·10
CO_2	nil	0·09	nil	0·21
TiO_2	0·56	1·46	1·07	1·20
P_2O_5	tr.	0·16	0·22	0·14
MnO	0·36	0·23	0·14	0·15
(Ni, Co)O	—	0·04	—	—
S	—	—	—	0·02
Cl	—	—	—	nil
F	—	—	—	nil
	99·82	100·04	100·20	99·99

1. Tremolite-epidote-greenstone, stones dredged near the Shag Rocks, 130 miles west of South Georgia. Anal. F. Herdsman.

A. Porphyritic basalt (Porphyritic Central Type), Mull. Anal. E. G. Radley. Quoted from 'The Tertiary and Post-Tertiary Geology of Mull', *Mem. Geol. Surv., Scotland*, 1924, p. 24.

B. Olivine-basalt (Recent), Penguin Island, King George Island, South Shetlands. Anal. F. Herdsman. See this Memoir, p. 59.

C. Chlorite-actinolite-clinozoisite-albite-schist, Clarence Island. Anal. E. Klüver. See this Memoir, p. 87.

The West Antarctic rock to which the Shag Rocks greenstone shows most resemblance is the schist from Clarence Island (Table 7, col. C). There is obviously a close mineralogical similarity, and the chemical analyses have the same pattern, although SiO_2 is lower and (Fe, Mg)O higher, in the Clarence Island rock. The latter, however, is of more advanced metamorphic grade than the greenstone of the Shag Rocks. From Tierra del Fuego, Kranck (*op. cit. supra*, pp. 43, 47, 54, 110) has described several ophiolitic greenstones, greenstone-schists, prasinites, etc., containing chlorite, epidote, actinolite, sphene, leucoxene, and albite, but the only analysis given of these rocks (cited in Table 6, col. A) does not accord very closely with that of the Shag Rocks greenstone.

The chemical affinities of this rock clearly accord with those of a common type of basalt, and it may be regarded as due to low-grade metamorphism of basaltic rocks of this type. Its association with quartz veins, and with a quartzite-like rock, and its chemical and mineralogical similarity to the prasinitic schists of Tierra del Fuego and Clarence Island, make it congruous with the whole assemblage of rock types found in the Scotia Arc, and adds confirmatory evidence for the theory of tectonic connexion between South America and West Antarctica favoured by E. Suess and other writers (see this Memoir, p. 89).

PART V. PETROGRAPHY OF THE SOUTH SANDWICH ISLANDS

INTRODUCTION

The volcanic South Sandwich Islands are situated at the extreme eastern end of the Scotia Arc, and form either a part of it, or a volcanic arc parallel to and in echelon with it. They are fully described in a recent publication to which reference will be frequently made in the ensuing pages.[1] It is proposed in this paper to summarize and collate the already published petrographic data, and to supplement them with descriptions of new material from five localities, viz. material collected *in situ* by Mr G. Rayner on Saunders Island, and dredgings from four stations: (1) St. 363, $2\frac{1}{2}$ miles S. 80° E. of the south-eastern point of Zavodovski Island, (2) St. 366, off the south coast of Cook Island, (3) St. 368, in Douglas Strait between Cook Island and Thule Island, (4) St. 370, 2 miles north-east of Bristol Island. In addition, there are some stones collected from a piece of floating ice near Bristol Island.

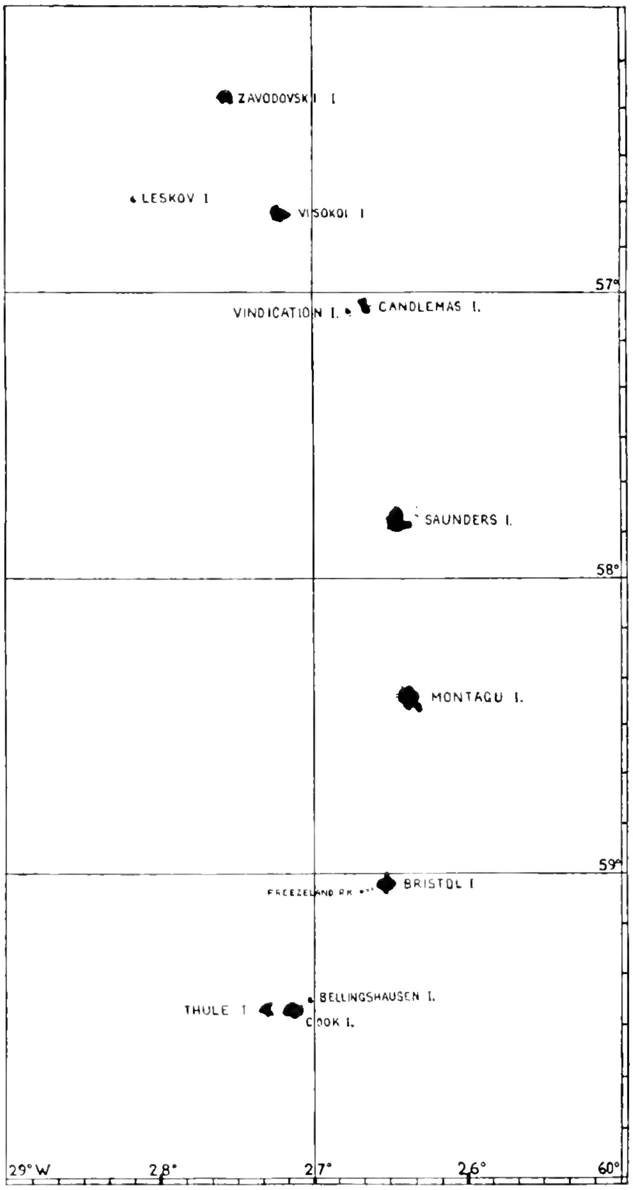

Fig. 14. The South Sandwich Island.

Many observations on the volcanology and on the rocks of the South Sandwich Islands as seen from a distance are published in the above memoir, but the only petrographic data so far published are to be found in the following three papers:

(1) O. Bäckström. 'Petrographische Beschreibung einiger Basalte von Patagonien, Westantarktika, und den Süd-Sandwich Inseln', *Bull. Geol. Inst. Upsala*, XIII, pp. 115–82 (1915). South Sandwich Islands, pp. 163–76.

(2) G. V. Douglas and W. Campbell Smith. 'Zavodovski Island, and Notes on Rock Fragments dredged in the Weddell Sea', '*Quest*' *Exped. Report* (*Brit. Mus. Nat. Hist.*), pp. 63–7 (1930).

(3) G. W. Tyrrell. 'Report on Rock Specimens from Thule Island, South Sandwich Islands', *South Sandwich Islands Memoir*, pp. 191–7 (1931).

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[1] Stanley Kemp and A. L. Nelson, 'The South Sandwich Islands', *Discovery Reports*, III, pp. 133–98, pls. xi–xxxi (1931). Hereinafter referred to as *South Sandwich Islands Memoir*.

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General. The South Sandwich Islands, so far as present observations go, are composed exclusively of Recent volcanic rocks, the products of present-day and recently extinct volcanoes. Five of the islands, Zavodovski, Candlemas, Bellingshausen, Saunders, and Visokoi (map, Fig. 14), show definite signs of volcanic activity and emit vapour and fumes; another three, Leskov, Vindication, and Montagu, show no activity at present, although large areas of ice- and snow-free ground, indicating residual warmth, exist on the islands. The remaining islands, Bristol, Cook, and Thule, are heavily glaciated, and show no signs of volcanic activity or warm ground.[1]

The *South Sandwich Islands Memoir* (p. 150) states that the rocks consist mainly of 'reddish tuff and black basaltic lava', and this is supported by the petrological examination of the collected rocks. The 'reddish tuff' may include reddened slags, and the lavas, while mainly basaltic, include basic andesites and even more acid types such as dacite. A possible exception to this generalization is Freezeland Peak, a small islet to the west of Bristol Island, which is referred to later (p. 99). It is proposed to describe the petrography of each of the islands in turn, starting from the northern end of the chain.

Zavodovski Island (*South Sandwich Islands Memoir*, pp. 156–60). This island is nearly circular in outline and is 9 miles in circumference. It consists mainly of an active volcanic cone which rises from a lowlying plateau of black basaltic lava most conspicuous on the eastern side of the island. There are subsidiary craters on the slopes of the main cone, and to the south of West Bluff there are fumaroles in reddish ground with some patches and streaks of sulphur. At one point horizontal strata apparently consist of alternate beds of ash and tuff.

In 1908 the Norwegian, Capt. C. A. Larsen, landed on many of the South Sandwich Islands and collected rock specimens of which, unfortunately, some were lost by accident. The collection was presented to Göteborg Museum, and was later described by O. Bäckström (1). Larsen landed at the north-west end of Zavodovski Island, which was found to consist of a porous lava carrying zeolites in the vesicles. These specimens were lost by the upsetting of the boat. Only a few small pebbles and lapilli were retained, which Bäckström identified as olivine-basalts and their tuffs. The fragments of which the latter were composed showed fresh phenocrysts [feldspars?] in a ground-mass which had been altered by the action of solfataric gases. Their richness in phenocrysts and in shattered basaltic ground-mass material showed that they represented a common type of 'Aschentuff' which was probably rather glassy.

During the Quest Expedition of 1921 G. V. Douglas saw the island at close range although he was unable to land (2). He does not state from which direction the 'Quest' approached the island, but from the fact that he mentions a cliff 40 ft. high with a long gentle slope inland, it may be assumed that he saw the low plateau on the eastern side. Douglas states that: 'The lava flows seen on the cliff face appeared to consist of a compact columnar basalt at the base. Above, there was a line of red cinder, and above this again what looked to be rough paehoehoe lava.'

Material obtained by dredging at 19 fm. corresponded with the above-described section. The sample consisted of rounded black pellets of diameters between 1 and 5 mm. Twenty of these were sectioned, and ten of them were found to consist of dense black glassy basalts free from olivine. Some were crowded with minute laths of plagioclase; others showed a few small phenocrysts of plagioclase and augite. Four of the pellets consisted of dense, dark brown, glassy olivine-basalts, some containing many crystals of plagioclase and only a few of olivine and augite. Four others were paler basalts of holocrystalline-porphyritic texture with small phenocrysts of plagioclase and sometimes augite in an

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[1] *South Sandwich Islands Memoir*, pp. 151–2.

intergranular ground-mass consisting of minute microlites of feldspar and grains of augite and magnetite. The two remaining pellets consisted of basalt glass of a deep olive-buff colour. In one of these microlites were absent, but in the other microlites of plagioclase and augite were abundant, and a little olivine was probably present.

The Discovery II material submitted to me was dredged at St. 363 from depths between 278 and 329 fm. at a locality 2½ miles S. 80° E. of the south-eastern point of Zavodovski Island. It consisted of two bags, one containing grey scoria or lapilli, very rough and angular, the largest being about 1 in. in greatest diameter; the other contained a few of the larger stones picked out from the scoria. Five thin sections were prepared from this material.

The scoria and lapilli consist of a highly vesicular, opaque, pumiceous glassy basalt. The glass varies in colour from black, even in thin section, to pale brown, and carries minute microlites of plagioclase and pyroxene, the latter being noticeably more abundant in the pale brown glass. A few large crystals are entangled in the glassy sponge; these include plagioclase (bytownite, An_{85}), pale brownish green diopsidic augite, and olivine, all perfectly fresh. In one specimen the glass is much haematitized, and carries much larger and more numerous feldspar microlites which can be identified as labradorite (An_{50}). These rocks are on the borderline between andesites and basalts. Their content of olivine is small and sporadic; and as the glassy ground-mass probably contains much free silica it may be presumed that if the magma had not been so rapidly quenched the olivine would have been made over into pyroxene by reaction, and the rock would then have been revealed as a basic andesite. This description agrees with that of the dredged material off Zavodovski given by Douglas (p. 93).

One of the dredged stones, however, the largest, is undoubtedly a sedimentary rock. It is a very dense, dark grey material which looks like cementstone. In thin section it shows a carbonate mineral intermingled with argillaceous matter. The rock effervesces only when powdered and treated with hot concentrated acid, and may therefore be identified as a dolomitic mudstone.

Leskov Island (*South Sandwich Islands Memoir*, pp. 161–2). This island, the smallest of the South Sandwich Group, lies some distance to the west of the arc on which all the other islands are situated. Its circumference measures only about 1½ miles. There is no record of any landing on this island, but it was observed at close range by Capt. Larsen ((1), p. 166), Lt. Filchner,[1] and by members of the Discovery II party. The last-named state that the island is crescentic in outline and is doubtless a fragment of a volcanic cone. Material dredged by Larsen at a depth of 75 fm. proved to consist of basaltic rocks ((1), p. 167). At the south-eastern corner of the island a conspicuous conical rock consists of columnar basalt; the cliffs round the southern and western sides are formed of rugged flows of basaltic lava inclined towards the sea on the south side at an angle of 45°, but gradually becoming vertical towards the west. The rock walls of Crater Bay are reddish and yellowish in colour and apparently consist of tuff which shows no definite bedding and is much contorted (*South Sandwich Islands Memoir*, p. 162).

Visokoi Island (*South Sandwich Islands Memoir*, pp. 162–5). This island is one of those that show definite volcanic activity. There is no known record of a landing and most of the information regarding Visokoi was obtained during the visit of 'Discovery II'. The only geological information available is that provided by a sketch of rock exposures on the north coast by Mr F. C. Fraser (*South Sandwich Islands Memoir*, fig. 8, p. 164), which shows columnar basalt, dark grey rock intersected by dikes and surmounted by light grey stratified rock [tuff?], reddish and grey rocks cut by dikes, and an exposure of stratified rocks [tuffs?] in alternate layers of grey and red tints. The general impression was that the rocks were basaltic lavas and tuffs similar to those seen on Zavodovski.

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[1] *Zum Sechsten Erdteil*, pp. 114–15, figs. 32–6 (Berlin, 1923).

Candlemas Group (*South Sandwich Islands Memoir*, pp. 165–72). This group consists of Candlemas Island itself, and a smaller one to the west which is now called Vindication Island. A full account of the geography and volcanic phenomena is given in the *Memoir*. A large collection of rock specimens from the southernmost point of Candlemas Island, made by Capt. Larsen, has been described by Bäckström in the following terms ((1), pp. 169–70, translated):

> [The rocks] are mostly reddish and porphyritic with rounded feldspars which sometimes give an almost white colour to the specimens. Under the microscope they are found to be extraordinarily rich in feldspar of composition An$_{65}$, which is zoned with glassy inclusions and shows both albite and pericline twinning. The main pyroxene is hypersthene which is often invested by monoclinic pyroxene, but both pyroxenes may occur as independent crystals. The augite shows the usual polysynthetic twinning, which is also seen in the investments around the hypersthenes. Strongly corroded olivine also occurs but is not common. It is mostly altered to a blackish brown dust, but all the other constituents are fresh. In regard to the systematic position of the rocks, their richness in plagioclase suggests that they represent a transition between the basalts and the andesites. It is difficult to assign some of the rocks to either group, but others which are richer in olivine and pyroxenes should be relegated to the basalts.
>
> Another type has an extremely fine-grained but holocrystalline texture. It is, however, little different to the above in mineral composition. Its plagioclase is lath-shaped not equidimensional, its pyroxene is sharply euhedral, and olivine is absent.
>
> Fragmental rocks also occur as very fresh, reddish brown, sandy tuffs which consist of lapilli of hazel-nut size. The latter consist of vesicular lavas with a glassy ground-mass full of crystallites, and carrying numerous crystals of plagioclase, augite, and hypersthene.

It will be seen how closely comparable these lavas and tuffs are to those of Zavodovski Island and Saunders Island (p. 96).

Members of the Discovery II party were not able to land on Candlemas Island, but they made numerous observations at close range, noting rugged flows of black basaltic lava in the northern plateau often showing columnar structure (*South Sandwich Islands Memoir*, pl. xvii, fig. 3). Mr F. C. Fraser has also provided an excellent sketch of rock exposures on the east coast (*ibid.* fig. 12, p. 169) showing what are obviously stratified tuffs and a coarse agglomerate.

It was found impossible to land on Vindication Island, but the geological structure of the island was well seen in a sheer cliff face on its north-western side. The rocks here consist of irregular masses of red and brown colours, presumably tuffs, cut by dikes of grey rock which run obliquely, vertically, and sometimes horizontally, not infrequently intersecting one another. Two islets, Cook Rock and Trousers Rock, both of which are tunnelled by wave erosion, show horizontal strata of red tuff and hard grey rock.

Saunders Island (*South Sandwich Islands Memoir*, pp. 172–4). Saunders Island, with a circumference of 17 miles, is one of the largest of the group, and is, perhaps, the best known geologically. At its centre is the glaciated but actively volcanic cone of Mt Michael (2640 ft.). The south-eastern part of the island is composed of bare hills (700–800 ft.) apparently consisting of loose ash or volcanic mud, and with several extinct craters. A very fine photograph of a half-section of a crater on the south coast is given in pl. xx, figs. 2 and 3, of the *Memoir*. The northern part of the island is a low plateau. All the rock exposures show that the basement of the island consists of columnar basalts similar to those of Candlemas and Zavodovski.

Capt. Larsen landed with difficulty on the south-eastern coast ((1), p. 170), and Bäckström describes the rocks collected here as, in the main, different from the type common in the South Sandwich Islands in being very dense and non-porphyritic. Under the microscope these rocks show a well-developed fluidal structure delineated by the alinement of the minute feldspar laths in the direction of flow. The mineral composition is plagioclase (An$_{55-65}$), almost colourless pyroxene in rounded grains which belongs to the enstatite-augite series, and magnetite. This rock is free from olivine, and a little analcite was found in one of the thin sections. A chemical analysis of the principal type, free from analcite, is published, which is set out with others from the South Sandwich Islands in Table 8 (p. 101) of this memoir. Bäckström calls the rock a basalt.

Owing to unfavourable conditions the Discovery II party was unable to land on Saunders Island, but on 28 November 1937, Mr G. Rayner was able to get ashore for a few hours from the 'William Scoresby'. He made some geological observations and collected a small number of rock specimens which are described below. The observations that follow are condensed from his MS. report.

Mr Rayner landed near the penguin rookery on the south side of Cordelia Bay (see Chart in the *South Sandwich Islands Memoir*, pl. xix). The beach material consisted of a loose black volcanic ash, the size of coarse sand or grit. Behind a low cliff of compressed snow heavily loaded with the same ash was a level area extending back to the hills. This platform consisted of a loose ash-like material to a depth of some inches, with occasional small boulders up to 18 in. in diameter of a heavy dark basaltic rock resting upon it.

From this point Mr Rayner walked along the shore eastward until he reached the first outcrop of hard rock which forms the basement of the Nattriss peninsula. Here he ascended the hill to the south near the point marked 800 on the Chart. On its northern slopes there were several outcrops of a soft volcanic mudstone with a sub-horizontal stratification, standing up as buttresses and ridges between steep-sided ravines. Mr Rayner thus gained a ridge which sloped eastward to Nattriss Point. The higher parts of this ridge still consisted of the stratified mudstone, which was undergoing extremely rapid atmospheric erosion. At one place he encountered a remarkable pillar 15–20 ft. high carved out of the soft material ('The Beacon'). Elsewhere along the ridge a light, vesicular, reddish, scoriaceous rock was found.

Descending eastward towards Nattriss Point Mr Rayner found that the rock became coarser in texture, and took on the appearance of volcanic tuff, light buff in colour, in which many large fragments of rock were embedded. This series of coarse tuffs rested on the roughly horizontal platform of dark, vesicular, basaltic rock of which Nattriss Point is composed. This rock falls in sheer cliffs to the sea and has a columnar appearance owing to wave erosion along vertical joints.

With, as the writer thinks, considerable probability, Mr Rayner concludes that 'a volcanic explosion has occurred at no very distant date, possibly from the crater to be seen to the south-west of our landing-place, and near the junction of the ice-covered main part of the island and the earthy region explored. This explosion has thrown up the clastic material forming the hill now resting on a horizontal table of rock of which Nattriss Point is the visible part. The finest material would be the last to settle, and this has formed the upper strata of soft mudstones seen in the fast dwindling ridges and buttresses along the hillside and in the pillar at the summit.'

Six thin sections were made from the specimens collected by Mr Rayner. The lava which forms the basement of the Nattriss peninsula is a black, highly vesicular rock which, in thin section, shows an abundant ground-mass of minute microlites of plagioclase with granules of augite and magnetite, within which is set a generation of somewhat larger feldspar laths, and finally a few micro-phenocrysts of feldspar and yellowish augite. Owing to their small size it is difficult to make out the composition of the plagioclase microlites of the ground-mass, but they give extinctions up to about 15 indicating a composition An_{30}. The larger microlites and micro-phenocrysts are highly zonal, and their composition ranges about An_{65}, which is the composition ascertained by Bäckström. The pyroxene, too, is zonal, as shown by an undulatory extinction. It is a pale yellow variety of moderate double refraction, and is probably, as Bäckström surmises, a member of the enstatite-augite series. The larger feldspars and pyroxenes, while occurring independently, are often aggregated into clots of which the feldspar forms the greater part, and the microlites of the ground-mass are stream-lined around these clots.

Olivine does not occur in this type which, owing to its feldspathic composition, would be better termed andesite than basalt.

Another specimen was taken from what appeared to be an inclusion within the above-described lava. It is not so dark in colour, but the thin section shows that it is the same lava with, however, a somewhat finer grain and a few sporadic olivine crystals, most of which are altered to green serpentine. This rock is probably a portion of the same lava, but consolidated slightly earlier than the main mass of the flow, and thus retaining a few of the early crystallized olivines. It may have been carried as a solidified lump of slag on the surface of the moving flow, and have been incorporated in it by over-rolling.

The coarse agglomeratic tuff which overlies the lava basement of the Nattriss peninsula is a well-consolidated material of light buff colour containing numerous fragments of gravel size. In thin section it proves to be a coarse lithic tuff consisting mainly of large angular fragments of the lavas embedded in a matrix of smaller fragments and broken crystals. The lava fragments are vesicular andesitic basalts of the same type as that described above, but they show every gradation of texture from purely glassy to holocrystalline-micro-granular. The broken crystals include plagioclase, augite, and fresh olivine. Conspicuous among the rock fragments are glasses of a bright green colour. An isotropic or very feebly birefringent zeolite with cubic cleavage forms a scanty cement in some parts of the slide. This may be the analcite recorded by Bäckström ((1), p. 171). This rock must have been formed by an explosion in or under a fully consolidated lava, and it may be suggested that it was produced by renewed activity in a nearby volcano which had been temporarily sealed by a plug of solidified lava.

The volcanic mudstone which overlies the lithic tuff and forms the higher parts of the Nattriss peninsula, in contrast to the lithic tuff, is a vitric ash consisting almost entirely of small angular fragments of clear brown glass. The only other constituents are a few small fragments of feldspar, augite, and magnetite. This was undoubtedly formed by explosions within a still liquid lava. Hence the sequence of events pictured by Mr Rayner (p. 96) must be slightly amended. The vitric ash does not represent the finer, and the lithic tuff the coarser, material derived from one and the same explosion; but the lithic tuff probably represents the disintegration by explosion of a solidified plug, and the vitric ash a subsequent explosion within the liquid lava that welled up into the crater.

The coarse black sand at the landing-place in Cordelia Bay consists of angular fragments of brown glass often blackened with separated magnetite, and crystals, in about equal proportions. The crystals include plagioclase, augite, and olivine, the last-named being rather more abundant than usual. This material may have been formed by explosion in an olivine-basalt magma within which, while still liquid, crystallization had advanced to a considerable extent. Examination of a small pebble enclosed in the sample bears out this diagnosis. It is an olivine-basalt with large phenocrysts of labradorite (An_{60}), abundant fresh yellowish olivine, and some magnetite, in a very dense ground-mass consisting of augite granules and feldspar microlites, in which the augite is decidedly predominant.

Montagu Island (*South Sandwich Islands Memoir*, pp. 174–6). Montagu is the largest island of the group with a circumference of about 24 miles, and is one of the least well known. It contains what is probably the highest summit of the group, Mt Belinda (4500 ft.), almost certainly an extinct volcano. Montagu is the most heavily glaciated island of the arc, and has fewest signs of residual warmth in the shape of areas free from snow and ice.

The Discovery II party did not land on the island, but they had the opportunity of making the following observations on the rock exposures as seen from a distance:

As on other islands the lowest strata seen in rock exposures are usually of black basalt, often columnar in structure, and it is of basalt that the outlying rocks are formed. Above it red and yellowish tuffs with some hard grey rock are

> to be found. At several points the rocks are clearly stratified, showing three or more horizontal layers of dark grey rock separated by narrow bands of red tuff. Sometimes yellow tuff with red inclusions was to be seen and frequently the rocks were much contorted and intersected by dykes. At the north-eastern corner of the island are low cliffs formed of a light grey rock, perhaps volcanic ash. (*South Sandwich Islands Memoir*, p. 175.)

Capt. Larsen landed at the south-eastern corner and mentions a crater here, as well as at the north-eastern point of the island. Bäckström ((1), p. 175) described the rocks collected as rather uniform types of vesicular olivine-basalts in which phenocrysts of olivine, augite, and plagioclase (An_{55}) predominate over the ground-mass. The ground-mass consists of small granules of pyroxene, laths of plagioclase, and some magnetite. The resemblance of these rocks to the olivine-basalt of Saunders Island (p. 97) is obvious.

Bristol Island (*South Sandwich Islands Memoir*, pp. 176–8). Bristol Island is an irregular oval in shape and has a circumference of 14 miles. The highest point is Mt Darnley (3600 ft.). Its profile seen from the north has the shape of a horse-shoe, and is conjectured to represent part of the rim of a crater. Bristol Island is heavily glaciated and the Discovery II party were satisfied that all volcanic activity had ceased. Three rocky islets, Grindle Rock, Wilson Rock, and Freezeland Peak, stand in line off the western coast of the island.

Capt. Larsen landed on the north-eastern side of the island[1] and collected some rock specimens. Bäckström ((1), pp. 175–6) describes them as of reddish grey tints, and as showing numerous small crystals of feldspar. In thin section numerous micro-phenocrysts of zonal plagioclase are disclosed, of composition An_{75-85}. Pyroxene is confined mainly to the ground-mass and belongs to the enstatite-augite series. Olivine is only sparingly present. A photomicrograph of this andesitic basalt type is given by Bäckström ((1), fig. 20, p. 176). It conforms closely to the main type of lava erupted from the South Sandwich Islands volcanoes.

Although no landing was made, the geological observations made by the Discovery II party (*South Sandwich Islands Memoir*, p. 177) are important and must be quoted in full:

> The rocks on Bristol are similar to those on the other islands. At Fryer Point black basaltic lava is to be seen and the rock exposures on the bluff on the south side, at the western headland and in other parts, are of yellowish and red tuff, or tuff conglomerate, sometimes stratified with a grey rock interposed between the layers, but frequently much contorted and with many intrusive dykes.
>
> From a geological point of view the three large outlying rocks appear to be more interesting than any other place in the entire group of islands....The great pillar on Freezeland is composed of a pale brown rock of a kind not seen elsewhere. It showed distinct signs of bedding and in the upper part of the column some broad reddish bands. We believe this may be a sedimentary rock. The eastern part of Freezeland, forming the lesser of the two summits, is different; it is formed of a brownish rock, with vertical fissures and striation, and may be metamorphic. Wilson Rock, nearer the mainland, is a vast mass of black columnar basalt, while Grindle Rock repeats the reddish and yellowish tuffs seen on the adjacent headland of the island. Thus, if our conjectures are correct, the whole succession of rock formations in the Sandwich group is to be found in these three islets. Freezeland shows the only likely exposure of the underlying sedimentary series that we know to exist, Wilson is of the overlying basalt, here seen in far greater thickness than elsewhere, while Grindle is formed of the superposed tuffs which are characteristic of all the islands of the group.

Among the material from the South Sandwich Islands submitted to the author there were specimens from near Bristol Island. One of these was a bag of scoria and lapilli dredged from St. 370 at a point two miles north-east of Bristol Island, and a bag of small stones, including lapilli, which were picked off a piece of floating ice near the island.

A thin section of the dredged scoria from St. 370 shows that it is a sponge of opaque black glass with minute microlites of feldspar and augite, and a few micro-phenocrysts of plagioclase (An_{80})

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[1] The position of the landing-place is mentioned in Bäckström's memoir ((1), p. 175). Cf. *South Sandwich Islands Memoir*, p. 178.

entangled in it. This seems to represent an extremely vitreous phase of the andesitic basalt lava described by Bäckström, and carries the same lime-rich feldspar.

Most of the smaller fragments recovered from the piece of floating ice answer to the above description. A larger stone, however, is 2 in. in length and presents a microscopic appearance very similar to that of the 'feldspathic basalt' described and figured by Bäckström. It shows very numerous micro-phenocrysts of plagioclase (An_{75-80}) with subordinate augite and olivine, in a dark glassy ground-mass carrying microlites of feldspar and augite. All the phenocrysts are perfectly fresh and euhedral. The augite is a yellowish, slightly-pleochroic variety belonging to the enstatite-augite series. In this rock the olivine is much more abundant than in Bäckström's material, and it must be regarded as an olivine-basalt.

Two other stones are interesting, as they are non-igneous. One is a fragment from a quartz-vein rock, and the other is an epidote-biotite-gneiss. In thin section the latter shows a coarse mosaic of quartz and orthoclase alternating with folia consisting of straggling crystals of bright yellow biotite and epidote (with some clinozoisite). There is also a little ilmenite altering to sphene, and a few fragments of deep green pleochroic hornblende. It is not possible to say whether this is an orthogneiss or a paragneiss. The mineral composition favours the orthogneiss interpretation, but an arkose would yield this type of gneiss on metamorphism.

The label attached to the material from floating ice does not state on which side of Bristol Island it was recovered. As the metamorphic fragments were closely associated with scoria which indubitably came from Bristol Island, it seems probable that they too were derived from that locality. It is possible that the metamorphic pebbles came from Freezeland Peak which the Discovery II party believed to consist of sedimentary and metamorphic rocks.

Southern Thule Group (*South Sandwich Islands Memoir*, pp. 178–89). This group consists of three islands, Thule, Cook, and Bellingshausen, in order from west to east. Of these, Cook Island is the largest, having a circumference of 9½ miles; Thule, the next largest, is more embayed than Cook and has a coastline of 10 miles; Bellingshausen, the smallest, is only 1½ miles wide.

Bellingshausen is still an active volcano, as shown by the steam and vapour rising from it, and by the admirable sketches of Lt.-Cmdr. J. Irving (*South Sandwich Islands Memoir*, fig. 19, p. 184). Cook and Thule, however, are buried beneath thick ice caps and there are no signs of present volcanic activity. Nevertheless, soundings in Douglas Strait between Thule Island and Cook Island have disclosed a steep-sided basin of elliptical shape and more than 400 fm. in depth. At the north and south entrances to Douglas Strait the depths are less than 20 fm. This has been interpreted, correctly in the writer's opinion, as the inundated crater of a volcano of which Thule Island and Cook Island are the remnants. This view is reinforced by the parallelism of the eastern embayment of Thule Island, and the western embayment of Cook Island, with the adjacent contours of the submerged basin (*South Sandwich Islands Memoir*, fig. 16, p. 179), and by the photograph of the eastern side of Thule Island (*ibid.* pl. xxx, fig. 4), which shows bedded lavas and ashes dipping westward and outward from the Douglas Strait crater.

Of the geological constitution of the Southern Thule Group little is known. On Bellingshausen the Discovery II party noted, as on other islands, black columnar basalt with overlying agglomerate, tuff, and ashes.

Cook Island (*South Sandwich Islands Memoir*, pp. 185–6). Rock faces are exposed in the cliffs bordering Douglas Strait. They are described as of yellow, red, or brown colours, sometimes showing signs of bedding but always much crumpled and contorted, and seamed with dikes of grey rock. Large, apparently intrusive, masses of brown rock showing a vertical striation were also seen.

Fortunately, however, some stones were dredged by 'Discovery II' at St. 366, 4 cables south of

Cook Island at depths between 155 and 322 m., and a few small fragments of rock at St. 368 in Douglas Strait, 1 mile north of the Twitcher Rock, dredged from a depth of 653 m. near the bottom of the great submerged crater. These pebbles, which consist mainly of slaggy and vesicular lavas, one or two being well rounded, range in size from about 2 in. in greatest diameter down to about $\frac{1}{2}$ in.

Sixteen of these stones were sectioned for microscopical examination. All of them were found to be textural variants of an olivine-basalt lava. Nearly holocrystalline varieties are grey and compact, and the glassy types black, vesicular, and slaggy, in hand specimens. In thin section these rocks are found to be highly porphyritic, carrying very numerous small phenocrysts of plagioclase, augite, and olivine, in a ground-mass consisting, when holocrystalline, of minute crystals of plagioclase, augite, and magnetite. In the more slaggy varieties the ground-mass becomes richer in dark glass and the number of microlites diminishes. In fact a complete passage from holocrystalline to a purely glassy ground-mass can be traced.

The plagioclase phenocrysts are generally most numerous, with augite and olivine following in that order; but in a few rocks the olivine almost rivals the feldspar in abundance. The plagioclase is both chemically and mechanically zoned and shows complex twinning; its composition ranges between An_{70} and An_{85}. The pyroxene is again the yellowish, slightly pleochroic variety of the enstatite-augite series. The olivine is perfectly fresh and often euhedral, especially in the more glassy varieties of the rock. It gives a dead straight isogyre and therefore contains about 13 per cent of the fayalite molecule.

This type is an olivine-basalt which compares closely with that from Bristol Island (p. 98), and with the younger basalts of the South Shetland Islands (e.g. Penguin Island, p. 46). A chemical analysis of one of the more holocrystalline types is recorded in Table 8 (p. 101).

Thule Island (*South Sandwich Islands Memoir*, pp. 187–9). The south-eastern plateau of Thule Island appears to be composed of the usual black columnar basalt. Near Cape Flannery on the west coast are beds apparently composed of yellowish tuff and ash, and farther north the rocks are definitely stratified, three layers of ash separated by red tuff overlying black basalt.

A landing was made by the Discovery II party on Beach Point at the north-eastern corner of the island. The ridge at Beach Point is composed of hard grey rock with outcrops of red tuff and a soft, crumbling, black rock, perhaps volcanic ash, at its summit. The steep cliffs facing Douglas Strait show contorted masses of red, yellow, and dark brown rocks with intrusive dikes.

Rock specimens collected here were described by the writer in an appendix to the *South Sandwich Islands Memoir* (pp. 191–7). Of the fifteen specimens, eight were obtained from exposures and seven were cobbles from the beach. Six rocks were obtained from an escarpment at 50 ft. above sea-level. Four of these were acid lavas (dacite) with good flow structures, and two were pyroxene-andesites containing both augite and hypersthene. As a black slaggy andesitic lava with red crusts was collected at 100 ft. it is inferred that the upper part of the cliff probably consisted of andesite while the dacites came from an underlying flow. At the top of the cliff, 150 ft. above sea-level, a true andesite-tuff was collected, which may represent the final explosive discharge of this volcanic episode. The beach cobbles and pebbles consisted mainly of dacites and andesites similar to those collected *in situ*. In addition there was a specimen of olivine-andesite (or andesitic basalt) and one of andesitic pumice.

Thule Island is therefore notable as providing the only acid lavas so far known in the South Sandwich Islands. The hypersthene-bearing andesites are also distinctive as they have hitherto only been recorded from Candlemas Island (p. 95). Analyses of dacite and hypersthene-andesite from Thule Island were published in the above Appendix, and are restated in Table 8 below.

CHEMICAL COMPOSITION OF LAVAS FROM THE SOUTH SANDWICH ISLANDS

Four chemical analyses of the lavas are recorded in Table 8, in order of decreasing silica percentage, along with comparable analyses of lavas from the South Shetland Islands, South America, and the West Indies. In the lower part of the table the von Wolff parameters as modified by the author (see p. 59) are given.

Table 8

	1	A	B	2	C	3	D	4	E	F
SiO_2	69·45	67·71	69·56	54·90	54·24	52·68	52·00	48·34	48·26	48·71
Al_2O_3	14·20	14·65	15·65	17·62	17·20	16·38	19·22	13·45	17·42	18·40
Fe_2O_3	2·83	1·59	1·24	2·70	2·81	3·11	2·73	1·12	3·36	3·70
FeO	3·24	3·29	0·91	6·80	4·98	7·98	5·61	11·34	5·61	5·25
MgO	0·25	0·85	0·82	3·93	5·84	7·47	5·54	6·62	8·83	10·30
CaO	3·05	2·34	2·52	9·05	10·19	8·08	10·58	11·43	11·56	10·11
Na_2O	4·15	6·09	4·09	2·90	2·91	2·75	2·53	2·22	2·44	2·34
K_2O	1·51	1·99	2·19	0·54	0·92	0·44	0·76	0·19	0·89	0·43
H_2O^+	0·40	0·16	2·92	0·30	0·09	0·20	0·20	2·94	0·24	0·25
H_2O^-	0·60	—		0·20			0·15	0·30	0·16	—
CO_2	nil	—	—	nil	—	—	nil	0·12	nil	—
TiO_2	0·15	1·00	—	0·70	0·91	0·77	0·63	1·47	1·07	1·08
P_2O_5	0·14	0·16	0·13	0·09	0·09	0·02	0·11	tr.	0·22	0·06
MnO	0·07	—	—	0·23	—	0·16	0·11	0·32	0·14	0·08
(Ni, Co)O	nil	—	—	nil	—	—	—	—	—	—
S	tr.	—	—	tr.	—	tr.	—	—	—	—
Cl	—	—	—	—	—	0·05	—	—	—	—
	100·04	99·83	100·03	99·96	100·18	100·09	100·17	99·86	100·20	100·71
Q	34·6	20·1	34·7	10·1	5·3	3·6	3·5	− 1·0	− 5·2	− 3·6
F′	44·3	62·5	49·2	27·3	29·3	25·1	25·5	19·3	25·0	21·7
M′	21·1	17·4	16·1	62·6	65·4	71·3	71·0	81·7	80·2	81·9
nak	62·6	82·6	67·9	30·1	33·7	30·4	26·1	28·0	28·6	23·9
k	19·3	17·7	25·9	9·6	17·5	8·2	16·3	5·4	18·4	11·6

1. Dacite (Dacitoid) lava, Beach Point, Thule Island, South Sandwich Islands. Anal. F. Herdsman. Quoted from G. W. Tyrrell, 'Report on Rock Specimens from Thule Island, South Sandwich Islands', *South Sandwich Islands Memoir* (1931), p. 192.

A. 'Trachyandesite' (Gourdon); Santorinite (Barth and Holmsen), Deception Island, South Shetland Islands. Quoted from E. Gourdon, *C.R. Acad. Sci., Paris*, CLVIII, p. 1906 (1914). Also see this Memoir, p. 58.

B. Dacite, Guaitara Slope, Loma de Ales, Colombia. Quoted from J. P. Iddings, *Igneous Rocks*, II, p. 496 (1913).

2. Hypersthene-andesite lava, Beach Point, Thule Island, South Sandwich Islands. Anal. F. Herdsman. Quoted from G. W. Tyrrell, *op. cit. supra*, p. 195.

C. 'Basalt' (Gourdon), Bridgeman Island, South Shetland Islands. Quoted from E. Gourdon, *op. cit. supra*, p. 1906. Also see this Memoir, p. 59.

3. 'Olivine-free basalt' (Bäckström), Saunders Island, South Sandwich Islands. Quoted from O. Bäckström, *Bull. Geol. Inst. Upsala*, XIII, p. 173 (1915).

D. Olivine-basalt lava, South Soufrière Hill, Montserrat, West Indies. Anal. F. Herdsman. Quoted from A. G. MacGregor, 'The Volcanic History and Petrology of Montserrat...', *Philos. Trans.*, Ser. B, CCXXIX, p. 74 (1938).

4. Olivine-basalt lava, Cook Island, South Sandwich Islands. Anal. F. Herdsman. New analysis.

E. Olivine-basalt lava, Recent volcano, Penguin Island, King George Island, South Sandwich Islands. Anal. F. Herdsman. New analysis (see this Memoir, p. 59).

F. Labradorite-basalt, Chateaubelair, St Vincent, West Indies. Quoted from A. Lacroix, 'Les caractéristiques lithologiques des petites Antilles', *Livre Jubilaire, Soc. Géol. Belge*, pp. 387–405 (1926).

There is a wide gap between the dacite (no. 1) and the prevalent andesitic and basaltic lavas (nos. 2, 3, 4) of the South Sandwich Islands—a gap which may be filled by future collections, although it seems probable that all of the islands are built mainly of the basic lavas. Comparatively high lime is characteristic of the whole series, including the dacite in which the *nak* ratio is only 62·6. Another general feature is the low F'/M' ratio (less than 0·5) in the prevalent basic lavas. This is in agreement with the Recent basalt lavas of the South Shetlands, but is in strong contrast with the equivalent lavas of the Andes, in which the F'/M' ratio fluctuates round about unity. It is a remarkable and perhaps significant fact that West Indian or Antillean lavas agree best with those of the South Sandwich Islands in this respect (cols. D and F, Table 8).

The dacite of Thule Island (Table 8, col. 1), while of sodic type, does not compare very well with the analogous santorinites of Deception Island (this Memoir, p. 58). Comparing the *nak* ratios (Table 8, cols. 1, A) it is seen to be much less alkalic than the Deception Island rock, and that entails a much larger amount of free silica (Q). It compares rather closely, however, with an Andean dacite from Colombia (Table 8, col. B). The hypersthene-andesite of Thule Island (Table 8, col. 2) compares fairly closely with the Bridgeman Island basalt (Table 8, col. C), but no Andean lava of like silica percentage could be found with even an approximately similar F'/M' ratio. Bäckström's 'olivine-free basalt' from Saunders Island (Table 8, col. 3) finds its closest analogue in an olivine-basalt from Montserrat (Table 8, col. D). The olivine-basalt of Cook Island (Table 8, col. 4) is only slightly undersaturated ($Q = -1{\cdot}0$), notwithstanding its comparatively large content of olivine. This illustrates its affinity with the more basic types of andesite. It compares well with the olivine-basalt lava of the Penguin Island volcano (Table 8, col. E), with the exception that it is slightly less undersaturated and somewhat more potassic than that rock. Again, the closest analogue of this rock is a labradorite-basalt lava from St Vincent in the West Indies (Table 8, col. F).

It would appear, therefore, that the predominant basic lavas of the South Sandwich Islands show closer affinities with the comparable rocks of the Antilles than with those of the Andes. This may, in turn, be regarded as evidence in favour of the view that the South Sandwich Islands do not lie on the main line of the Scotia Arc, but form an easternmost ridge parallel to and in echelon with it. On this view the main line of the Scotia Arc may curve southward from the eastern end of South Georgia and join up with the South Orkneys. The most recent chart of the Scotia Sea[1] shows South Georgia trending to the south-east away from the line connecting it with the South Sandwich Arc, and pointing towards a marked northerly projection of the 3000 m. depth-contour which, in turn, leads towards the South Orkney Islands.

Of the basement on which the volcanoes of the South Sandwich Islands stand we possess only very exiguous and doubtful scraps of information, namely, a comparatively large piece of dolomitic mudstone dredged off Zavodovski Island (p. 94), and fragments of epidote-biotite-gneiss and vein quartz taken from a piece of floating ice near Bristol Island (p. 99). Any future geological exploration of the islands should therefore include search for exposures of this foundation, and examination of coarse fragmental igneous deposits for non-volcanic material which may be presumed to have been derived from the basement. The latter line of research is much more likely to be fruitful than the former, except perhaps on Bristol Island.

Acknowledgements. The author's thanks are due to the Discovery Committee for defraying the cost of the new rock analyses published in this work, to Prof. W. J. McCallien, D.Sc., for re-drawing Fig. 8, p. 60, to J. M. Wordie, M.A., for his valuable introductory Foreword, and to Dr N. A. Mackintosh for his editorial vigilance during the progress of this Memoir towards publication.

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[1] H. F. P. Herdman, 'Report on Soundings taken during the Discovery Investigations, 1926–32', *Discovery Reports*, VI, pl. xlv (1932).

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THE DEVELOPMENT AND LIFE-HISTORY OF ADOLESCENT AND ADULT KRILL, *EUPHAUSIA SUPERBA*

BY

HELENE E. BARGMANN, PH.D.

CONTENTS

THE DEVELOPMENT AND LIFE-HISTORY OF ADOLESCENT AND ADULT KRILL, *EUPHAUSIA SUPERBA*

By Helene E. Bargmann, PH.D.

(Text-figs. 1–3)

INTRODUCTION

THIS paper is an extension of my short one, published in 1937. The stages in the development of the reproductive system described therein have been used here to work out the composition of the euphausian population as a whole and its growth rate. This method was first employed by Ruud, but as he was handicapped by lack of material he could not carry his work quite far enough. I have been more fortunate in having access to the very extensive Discovery Collections; indeed, there has been more material than I could cope with single-handed, and some selection became necessary. My object has been to obtain as complete a series of observations as possible throughout the whole year. Unfortunately, weather and ice conditions in the Antarctic make it difficult to fish nets in autumn and winter. The material for this time of the year is consequently very scanty compared with that for the spring and summer months, when there was such great abundance that I could not examine it all. The voyages of the two ships, R.R.S. 'Discovery II' and R.R.S. 'William Scoresby', have covered between them the whole of the Antarctic zone, but their programme of work has kept them so continually on the move that regular observations in definite localities are not available in consecutive months. I have therefore had to combine material from different regions and different seasons in order to obtain records extending over all the months of the year, and even so the material for the month of July is so scarce as to be negligible. However, it is reasonable to conclude that, by using material for several seasons, a very fair general idea of the average conditions in which *Euphausia superba* grows and breeds is obtained.

MATERIAL AND METHODS

Material collected over a period of ten years was used. The method of examining specimens was the same as that described in my previous paper. Each specimen was measured to the nearest millimetre from the anterior margin of the eyes to the tip of the telson; the carapace was then opened under a binocular microscope and the stage of development of the reproductive system was determined, external sexual characters also being noted: 8029 specimens were measured and dissected in this way.

The results of this intensive investigation are all set out in the appendix. The total catch from each station has been divided into males and females, which are tabulated separately. All particulars of length and internal and external development are given, together with the totals of the different stages. Fraser's records of eggs and early larvae have been added to the lists of females to show as clearly as possible the correlation between the occurrence of adults and eggs.

No statistical tests of validity have been applied to calculations of the average lengths of the different stages, because the stages are in themselves always anatomically distinct. Nor have any formulae been used in working out the curve of growth. There are too many factors involved for any of the existing mathematical methods to be applied with any certainty. As Ottestad (1933) writes: "In the course of our studies of the problems of growth, it has gradually become manifest to us that, with our present knowledge of the numerous factors determining growth, the problem of finding a law that will explain the whole chain of causes upon which growth depends is for the time being insoluble."

ACKNOWLEDGEMENTS

I am fortunate in having been able to discuss various problems arising during the course of this work with Dr N. A. Mackintosh and with Dr F. C. Fraser, and I am very grateful for their criticism and advice. My colleagues, Dr T. J. Hart and Miss D. M. E. Wilson, have helped me in many ways, the former by his work on the phytoplankton of the Antarctic zone, and the latter by her constant interest and the practical way in which she has helped me to reduce the large body of evidence into manageable shape.

DEVELOPMENT

LARVAL KRILL

During the first year of growth, *Euphausia superba* passes from the egg through the successive larval stages of nauplius, metanauplius, calyptopis and furcilia, until it enters upon its second year of post-larval or adolescent life.

Its larval history has been dealt with in detail by Fraser (1936) in his paper on the "Development and distribution of the young stages of krill (*Euphausia superba*)". A summary of his work and a comparison with the observations of Taube and Lebour on euphausians of the northern hemisphere must be given here, in order to present as complete a record of early growth as possible.

Fraser obtained, by analysis of plankton samples, records of eggs and their occurrence extending from the first part of November to the latter part of March, a period of four and half months. Just before laying, the eggs of *E. superba* are so tightly packed that, on the outer surface of the ovary, they are approximately pentagonal or hexagonal in shape, while on the inner side they are roughly conical. I have measured sixty eggs from two gravid females, and I find that their average diameter is 0·55 mm., although their greatest diameter may be as much as 0·68 mm. or even 0·72 mm. (Ruud, 1932), but that, after laying, the eggs assume a spherical shape with a consequent adjustment in size, those found in the plankton and examined fresh measuring 0·60 mm.

Fraser states that "eggs occurred in the plankton showing all stages of development, culminating in the clearly distinguishable form of the 1st nauplius". Only two free-swimming specimens of the 1st nauplius were obtained, one measuring 0·63 mm. in length and the other 0·66 mm. These were caught during the second half of December, together with three 2nd nauplii, measuring 0·65, 0·68 and 0·70 mm. respectively. "The rarity of 1st and 2nd nauplii and the smallness of numbers where records exist may indicate that these stages are passed through very rapidly in this species, as in other euphausiids where the development is known".

Taube (1915) and Lebour (1926) found that in northern waters the euphausian egg can develop into the metanauplius within a few days. Observations on *Nyctiphanes norvegicus* indicate that the free-swimming nauplius is hatched from the egg three days after laying, and that by the fifth day the limbs have taken on the metanauplius form, but that the mandible and lower lip characteristic of the fully developed stage do not appear until about the fourteenth day.

Metanauplii occurred in the Discovery material in fair numbers from February onwards, very big catches being obtained at two stations in March. The average length of the larvae at this stage is approximately 0·95 mm.

The measurements of these early developmental forms show that the larvae do not grow very rapidly until they begin to feed independently. Sars (1898) thought that this occurred in the metanauplius, when the mouth opens to the exterior; but Taube has shown that at this stage, in *Nyctiphanes norvegicus*, there is as yet no connexion between the mouth and the mid-gut, and Macdonald (1927) states that, in *Meganyctiphanes norvegica*, "although an open mouth is present in the metanauplius it was not found to feed". The internal yolk supply suffices until the gut is fully established. This occurs after the calyptopis stage is reached, when the mouth and proctodaeum become connected with the mid-gut. The cells of the mid-gut still contain a certain amount of yolk, but Sars (1898) writes that the larva now begins to feed actively, "chiefly upon small Diatomeae, the remains of which could be distinguished by microscopical examination of the contents of the intestine". In *E. superba*, "the more typically oceanic species of diatoms are evidently digested rapidly: recognizable fragments are rather rare even in the crop (Hart, 1934)....Two forms that appeared constantly in the stomachs of adult specimens and remained clearly recognizable were *Fragillaria antarctica*[1] and *Thallassiosira antarctica*".

Table 1 has been compiled from the data in Fraser's paper and gives the average lengths of the different larval stages. It will be noticed that at the 1st calyptopis stage, when the larva begins to feed, its length is at once almost doubled, after which growth proceeds again more regularly throughout the summer. "By the time the euphausiid reaches the 6th furcilia stage, the major developmental changes have been effected and in appearance it is characteristically a euphausian."

Table 1. *Average lengths of larval stages*

Stage	Average length of larvae in mm.	Stage	Average length of larvae in mm.	Stage	Average length of larvae in mm.
Egg	0·60 (diameter)	2nd calyptopis	2·71	3rd furcilia	7·32
1st nauplius	0·65	3rd calyptopis	3·98	4th furcilia	8·01
2nd nauplius	0·67	1st furcilia	4·50	5th furcilia	9·52
Metanauplius	0·95	2nd furcilia	5·11	6th furcilia	11·34
1st calyptopis	1·71				

By plotting half-monthly average lengths of the larvae for the period of one year, Fraser found that from November to March (the period of spawning) growth was slow, but that it increased steadily from March to June, was retarded during the mid-winter months and began to increase again at the end of August, by which time the first adolescents had made their appearance. Evidently, growth from the egg of the adolescent occupies an average period of about nine months, although under optimum conditions it can proceed more rapidly.

Fraser's work on larval krill shows clearly that spawning in *E. superba* is not restricted to one short period, but is spread over most of the southern summer, with the result that new broods of larvae are continually being hatched out, and the stock is constantly replenished. Taube (1915) and Ruud (1936) found that in northern waters, *Nyctiphanes* and closely allied euphausians had a similarly extended spawning season. Consequently, eggs, larval forms, adolescents in every stage of development, and adult individuals can be, and frequently are, found to exist side by side, and the euphausian population presents a very heterogeneous appearance.

The larvae of *E. superba* after one year of growth have attained by the following November an average length of 13 mm. Their subsequent development from adolescence to maturity forms the subject of this paper.

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[1] Revised by Hendey (1937) and now called *Fragillariopsis antarctica*.

ADOLESCENT KRILL

Of the 8029 specimens of *E. superba* which I have examined, 6006 were adolescent and of these 3073 were males and 2933 females. The youngest adolescents first make their appearance in any number in August; they show no trace of external sexual characters, but internally the reproductive system is recognizable, and by dissection under a low-power binocular microscope the sex of each individual can be determined. I have described the development of the reproductive system in the short paper forming an introduction to this one, which has been published in vol. XIV of the *Discovery Reports*. It will therefore be sufficient to summarize this development here, before discussing how growth proceeds during adolescence.

Ruud (1932) has drawn attention to the fact that, in *E. superba*, investigation of the testis and ovary is the only reliable method of determining maturity, and that the reproductive system of each individual must therefore be examined before the composition of any specific population can be estimated. After examining the euphausian material obtained during the cruise of the S.S. 'Vikingen', he distinguished four stages of maturity in both males and females. These are listed in Table 2.

Table 2 (after Ruud). *Stages of maturity*

	Males		Females
1	No spermatophores visible in the ejaculatory duct (depository)	1	Ovary small and immature. Eggs 0·10–0·25 mm. in diameter
2	Visible spermatophores: not loosened by touching with a needle	2	Ovary large but immature. Eggs 0·26–0·50 mm. in diameter
3	Visible spermatophores: loosened when lightly touched	3	Ovary large and mature. Eggs 0·51–0·70 mm. in diameter
4	Empty ejaculatory ducts. Mating has recently taken place	4	Ovary small, mainly germinal layer. Eggs 0·54–0·65 mm. loose in thorax. Spawning has taken place

Ruud states that he does not know of "any practical method by which the degree of maturity of the testicle can be ascertained". Consequently, he included within stage 1 all those male euphausiids which were not fully adult (i.e. all those with no visible spermatophores in the ejaculatory ducts), and he found that the specimens showed a very wide range in length: 16·6–44·4 mm.

As a criterion of development in the females, he used the diameter of the egg, and again found great variation in length in the specimens included within stage 1.

It is clear that this first group of Ruud's, comprising as it does males and females of such different size, covers the whole period of adolescence, during which time the reproductive system becomes mature. A closer investigation of these adolescent forms has thrown more light on the development of *E. superba*.

ADOLESCENT MALES

Although during adolescence the individual growth rate varies very considerably, five stages can be distinguished in the development of the male sexual organs, both internal and external. These stages

Table 3. *Growth stages in the male*

Stage	Internal structures	Stage	External structures
1	Primitive condition. Small testis, simple uncoiled vas deferens	A	Undifferentiated 1st pleopod
2	Small posterior flexure appears on vas deferens	B	Petasma appears as an undivided lobe
3	Lateral pocket appears on posterior flexure	C	Petasma becomes divided into two lobes
4	Anterior flexure appears on vas deferens	D	Wing develops above petasma
5	Coiling on vas deferens near posterior flexure	E	Wing grows and curves over petasma

Table 4. *Size range in each developmental stage*

Month	Stage 1				Stage 2				Stage 3				Stage 4				Stage 5				Stage 6				Stage 7			
	Smallest specimen		Largest specimen		Smallest specimen		Largest specimen		Smallest specimen		Largest specimen		Smallest specimen		Largest specimen		Smallest specimen		Largest specimen		Smallest specimen		Largest specimen		Smallest specimen		Largest specimen	
	Length mm.	Ext. dev.	Length mm.	Ext. dev.	Length mm.	Ext. dev.	Length mm.	Ext. dev.	Length mm.	Ext. dev.	Length mm.	Ext. dev.	Length mm.	Ext. dev.	Length mm.	Ext. dev.	Length mm.	Ext. dev.	Length mm.	Ext. dev.	Length mm.	Ext. dev.	Length mm.	Ext. dev.	Length mm.	Ext. dev.	Length mm.	Ext. dev.
	Adolescent males																				Adult males							
Aug.	11	A	22	B	23	A	32	B	29	B	35	C	30	C	40	D	35	D	48	E	39	E	51	F	—	—	—	—
Sept.	13	A	15	A	23	B	29	B	30	C	32	C	33	C	40	E	34	D	46	F	40	F	55	F	52	G	57	G
Oct.	11	A	20	A	22	A	33	B	27	C	33	C	30	C	37	C	33	F	41	E	37	G	55	F	35	G	55	G
Nov.	10	A	30	A	21	A	30	B	32	C	36	C	30	B	42	D	39	E	45	E	35	G	45	F	39	G	55	G
Dec.	12	A	31	B	20	B	39	C	33	B	50	F	32	B	49	F	44	E	52	F	40	F	52	G	35	G	57	G
Jan.	18	A	30	A	25	B	45	B	34	B	55	E	34	C	53	F	40	D	53	F	48	F	—	—	44	G	58	G
Feb.	19	A	39	B	24	B	43	B	29	B	54	E	37	C	59	D	43	F	60	F	45	F	64	F	41	G	60	G
Mar.	20	A	29	B	24	B	46	C	34	C	52	D	40	D	52	E	37	E	55	E	48	F	57	G	48	G	58	G
Apr.	18	A	34	A	25	A	38	B	31	B	47	D	38	D	57	F	49	F	58	F	48	F	55	F	48	G	55	G
May	26	B	31	A	28	B	37	B	35	C	41	C	33	D	46	D	—	—	—	—	—	—	—	—	—	—	—	—
June	—	—	—	—	30	B	33	B	31	C	40	C	35	D	49	E	40	E	—	—	—	—	—	—	—	—	—	—
July	—	—	—	—	—	—	—	—	30	C	—	—	35	C	—	—	46	E	48	E	—	—	—	—	—	—	54	G
	Adolescent females												Adult females															
Aug.	10	A	25	A	21	B	37	C	29	B	45	D	33	D	42	E	42	E	55	E	—	—	—	—	—	—	—	—
Sept.	12	A	25	B	23	B	28	C	31	C	38	D	31	D	55	E	—	—	49	E	—	—	—	—	—	—	—	—
Oct.	11	A	20	A	25	B	44	D	22	C	40	D	30	D	50	E	38	E	56	G	—	—	—	—	—	—	—	—
Nov.	10	A	31	A	21	B	30	C	25	C	30	C	27	D	37	E	34	G	51	F	46	G	48	G	—	—	—	—
Dec.	12	A	37	C	20	A	36	B	28	B	—	—	33	E	44	E	30	G	58	F	32	E	60	G	55	G	61	F
Jan.	18	A	45	C	31	C	36	B	37	C	40	C	43	G	46	G	31	D	51	G	38	G	59	F	50	G	64	G
Feb.	16	A	46	C	24	B	48	C	31	B	49	C	—	—	—	—	37	D	55	F	42	G	60	G	40	G	50	G
Mar.	20	A	46	B	25	B	47	C	34	C	48	C	40	E	48	E	43	D	—	—	47	G	48	G	43	G	60	G
Apr.	23	A	41	C	26	B	40	C	29	B	46	D	35	D	46	E	—	—	—	—	43	E	50	G	41	G	55	G
May	22	A	32	B	26	B	39	C	37	C	45	D	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
June	27	A	32	B	30	B	44	C	36	C	49	E	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
July	—	—	—	—	26	A	30	B	29	B	41	D	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

Size range in adolescent ♂'s = 60 − 10 mm. = 50 mm.

Size range in adolescent ♀'s = 49 − 10 mm. = 39 mm.

Size range in adult ♂'s = 64 − 35 mm. = 29 mm.

Size range in adult ♀'s = 64 − 27 mm. = 37 mm.

have not been arbitrarily selected, but are part of the normal development of the reproductive system. I have dissected 3073 adolescent male specimens and have found that growth proceeds by the addition, in constant sequence, of definite anatomical structures. The appearance of each structure in turn marks a stage, but internal and external development do not necessarily keep pace with one another. These stages, five in number, tabulated below in Table 3, are collectively equivalent to the stage 1 of Ruud. Stages A–E are the approximate external equivalent of stages 1–5.

The majority of adolescents of stage 1 show no differentiation of the copulatory organs: that is to say, externally, development corresponds to stage A, the 1st pleopod being unmodified. In some cases, however, external growth proceeds more rapidly than internal, and the pleopod may carry a primitive, undivided petasma, stage B. The total number of adolescent males of stage 1 which I have dissected is 1211, and of these 1014 were at stage A externally and 197 at stage B.

Table 5. *Average length per month of each stage in mm.*

Month	Stage 1		Stage 2		Stage 3		Stage 4		Stage 5		Stage 6		Stage 7	
	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀
Aug.	13	13	26	29	32	35	35	39	40	46	44	—	—	—
Sept.	14	18	26	26	31	33	36	42	41	49	48	—	54	—
Oct.	15	15	28	29	31	29	34	40	37	45	43	—	44	—
Nov.	20	20	27	25	34	27	38	31	41	43	41	47	45	—
Dec.	23	23	28	31	40	28	42	39	47	45	46	46	51	57
Jan.	23	25	33	34	42	39	44	44	47	42	48	50	51	54
Feb.	25	28	33	32	43	36	49	—	53	46	54	50	52	52
Mar.	25	33	33	38	44	43	47	46	49	43	52	48	52	50
Apr.	28	32	31	33	40	40	46	42	53	—	51	47	52	47
May	28	28	32	31	38	41	41	—	—	—	—	—	—	—
June	—	30	32	36	37	41	41	—	40*	—	—	—	—	—
July	—	—	—	28*	30*	38	35*	—	47*	—	—	—	54*	—

* Neglect?

Average length of each stage per annum in mm. for the whole year

Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Stage 6	Stage 7
			Males			
22	31	41	43	45	47	50
			Females			
24	32	36	40	44	49	50

Individual length varies very considerably. Table 4 gives the monthly minimum and maximum lengths for all stages, and shows clearly that size alone is not necessarily a reliable criterion of development. In November, for example, the length of the individuals of stages 1 and A varies widely over a range of 10–30 mm., whereas in May the range is much narrower, lying between 26 and 31 mm. Nor is size always associated with a more advanced stage of internal development: in February, for example, a specimen measuring 39 mm. has a pleopod at stage B, but in May the largest specimen, measuring 31 mm., is only at stage A, while the small specimen (26 mm.) is already at stage B.

The *average* monthly length of the specimens, on the other hand, shows a steady increase throughout the year, starting at 13 mm. in August and reaching 28 mm. by the following May (see Table 5, which also gives the average length of each stage for the whole year).

This great variation in the size of individuals within a stage is characteristic of all adolescents, whether they are at stage 1 or at stage 5, or at any of the intermediate stages. By referring to Table 4, the whole range of size can be seen, while Table 6 gives the number of males and females in each stage per month and their degree of external development.

Of stage 2, 795 specimens were examined. The stage of external development of the majority of these (694) was stage B, though in 60 specimens the copulatory organs were as yet undeveloped (stage A). Among the largest specimens, more advanced external development was found, 40 specimens being at stage C and one even at stage D. This last specimen was not, however, the largest recorded; it measured 43 mm., whereas the greatest length found was 46 mm., this specimen occurring in March and being at stage C externally. The average length of stage 2 was 26 mm. at the beginning of the southern spring and a steady increase was maintained throughout the year, rising to a maximum of 33 mm. in March, with a slight drop to 32 mm. in June.

No specimens at stage 3 were found showing the primitive condition, stage A, of external development. The majority (268) were at stage C, 111 were at stage B, 150 at stage D, 36 at stage E and 5 at stage F (the first external stage usually characteristic of young adults), making a total of 570 in all. External development is beginning to run ahead of internal development, with the result that superficially some of the specimens appear to be approaching maturity. The maximum lengths in some months are similarly deceptive, in December to February the largest specimens being over 50 mm. The average monthly lengths, however, indicate steady growth to a size intermediate between young adolescents and adults; they increase from 32 mm. in August to 44 mm. in March, with a fall to 37 mm. in June.

Among the 311 males at stage 4, much the same conditions obtain. The largest specimens were well advanced in external development, being mostly at stages E and F, although the biggest one of all, measuring 59 mm., was only at stage D. The majority of the specimens (150) were also at stage D, while two specimens were at stage B, 47 at stage C, 85 at stage E and 27 at stage F. The average monthly length of stage 4 increases from 35 mm. in August to 49 mm. in February, to fall again through 47 and 46 mm. to 41 mm. in May and June.

Stage 5 is the last adolescent stage. After passing through it, the male specimens of *E. superba* can be regarded as being fully mature. In all, 186 specimens were examined, 19 being at stage D, 97 at stage E, 68 at stage F and 2 at stage G, externally these last two being fully developed, although not the largest specimens measured. The average length varies from 40 mm. in August through 37 mm. in October to a maximum of 53 mm. in February and April.

ADOLESCENT FEMALES

No special sequence of structural additions marks the growth of the female reproductive system. It has been pointed out already that Ruud used the diameter of the eggs as the criterion of development in the female. There is, however, a period of growth before the eggs themselves can be measured under an ordinary binocular dissecting microscope, during which time the ovary is clearly getting larger. I have found that during this period, it is possible to use the size of the ovary as an indication of maturity. Three stages are passed through before the eggs become of measurable size: these three stages mark the period of adolescence. The thelycum, the thoracic pouch into which the spermatophores are inserted, also passes through three stages before the adult condition is reached. These stages of growth are tabulated below. They are based on the examination of 2933 adolescent females.

The primitive, unlobed, saddle-shaped ovary can be distinguished in specimens as small as 10 mm., in which there is as yet no sign of the thelycum. It can also occur in specimens measuring 45 and 46 mm., in which the thelycum is at stage C. The average monthly length of the adolescents of stage 1 ranged from 13 mm. in August through 33 mm. in the following March to 30 mm. in June. The thelycum was undeveloped in the majority of the specimens. Out of 1796 examined, 1150 were at stage A, 403 at stage B, 220 at stage C, 21 at stage D and 2 at stage E, normally a stage characteristic of the adults, these last measuring 38 and 39 mm. respectively. The analyses of the measurements of adolescent females will be found set out in Tables 4–6.

Table 6. *Analysis of total catch into stages*

	No. of individuals in each stage per month							Total	No. of individuals in each stage per month							Total
	Stage A	Stage B	Stage C	Stage D	Stage E	Stage F	Stage G		Stage A	Stage B	Stage C	Stage D	Stage E	Stage F	Stage G	
Stage 1:	Adolescent males								Adolescent females							
Aug.	4	1	—	—	—	—	—	5	14	—	—	—	—	—	—	14
Sept.	7	—	—	—	—	—	—	7	6	12	—	—	—	—	—	18
Oct.	234	—	—	—	—	—	—	234	254	—	—	—	—	—	—	254
Nov.	182	—	—	—	—	—	—	182	211	2	—	—	—	—	—	213
Dec.	252	45	—	—	—	—	—	297	257	55	26	—	—	—	—	338
Jan.	199	—	—	—	—	—	—	199	191	40	9	—	—	—	—	240
Feb.	60	130	—	—	—	—	—	190	131	82	17	—	—	—	—	230
Mar.	54	9	—	—	—	—	—	63	70	111	74	20	—	—	—	275
Apr.	18	7	—	—	—	—	—	25	8	83	94	1	2	—	—	188
May	4	5	—	—	—	—	—	9	7	15	—	—	—	—	—	22
June	—	—	—	—	—	—	—	—	1	3	—	—	—	—	—	4
July	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	1014	197	—	—	—	—	—	1211	1150	403	220	21	2	—	—	1796
Stage 2:																
Aug.	14	22	1	—	—	—	—	37	6	32	28	—	—	—	—	66
Sept.	—	17	—	—	—	—	—	17	2	7	8	—	—	—	—	17
Oct.	4	29	2	—	—	—	—	35	—	4	10	1	—	—	—	15
Nov.	17	23	—	—	—	—	—	40	1	15	2	—	—	—	—	18
Dec.	—	79	3	—	—	—	—	82	2	2	3	1	—	—	—	8
Jan.	9	31	—	1	—	—	—	41	—	3	2	—	—	—	—	5
Feb.	—	297	19	—	—	—	—	316	135	142	25	2	—	—	—	304
Mar.	4	69	14	—	—	—	—	87	3	51	30	22	4	—	—	110
Apr.	12	102	1	—	—	—	—	115	7	46	13	3	2	—	—	71
May	—	21	—	—	—	—	—	21	—	28	6	—	—	—	—	34
June	—	4	—	—	—	—	—	4	—	14	11	3	—	—	—	28
July	—	—	—	—	—	—	—	—	1	2	—	—	—	—	—	3
Total	60	694	40	1	—	—	—	795	157	346	138	32	6	—	—	679
Stage 3:																
Aug.	—	5	19	—	—	—	—	24	—	9	37	58	6	—	—	110
Sept.	—	1	2	—	—	—	—	3	—	—	2	2	—	—	—	4
Oct.	—	2	21	—	—	—	—	23	—	1	26	25	2	—	—	54
Nov.	—	—	3	—	—	—	—	3	—	—	5	3	—	—	—	8
Dec.	—	11	4	5	—	3	—	23	—	1	—	—	—	—	—	1
Jan.	—	11	4	4	8	—	—	27	—	—	2	—	—	—	—	2
Feb.	—	50	85	44	25	—	—	204	1	99	22	2	—	—	—	124
Mar.	—	3	63	54	—	—	—	120	1	—	17	10	2	—	—	30
Apr.	—	26	53	41	3	2	—	125	—	17	16	13	4	—	—	50
May	—	2	4	1	—	—	—	7	—	—	3	3	—	—	—	6
June	—	—	9	1	—	—	—	10	—	—	27	26	8	—	—	61
July	—	—	1	—	—	—	—	1	—	3	1	4	—	—	—	8
Total	—	111	268	150	36	5	—	570	2	130	158	146	22	—	—	458
Stage 4:									Adult females							
Aug.	—	—	13	23	1	—	—	37	—	—	—	13	18	—	—	31
Sept.	—	—	1	1	2	—	—	4	—	—	—	8	25	—	—	33
Oct.	—	—	7	8	2	—	—	17	—	—	—	9	165	1	—	175
Nov.	—	—	5	17	2	—	—	24	—	—	—	7	8	—	—	15
Dec.	—	2	3	12	4	6	—	27	—	—	—	2	9	—	1	12
Jan.	—	—	4	9	2	3	—	18	—	—	—	—	—	1	2	3
Feb.	—	—	2	11	33	8	—	54	—	—	—	—	—	—	—	—
Mar.	—	—	1	30	9	1	—	41	—	—	—	5	12	1	—	18
Apr.	—	—	6	17	29	9	—	61	—	—	—	11	9	—	—	20
May	—	—	—	3	—	—	—	3	—	—	—	—	—	—	—	—
June	—	—	4	19	1	—	—	24	—	—	—	—	—	—	—	—
July	—	—	1	—	—	—	—	1	—	—	—	—	—	—	—	—
Total	—	2	47	150	85	27	—	311	—	—	—	55	246	3	3	307

Table 6 (*cont.*)

	No. of individuals in each stage per month							Total	No. of individuals in each stage per month							Total
	Stage A	Stage B	Stage C	Stage D	Stage E	Stage F	Stage G		Stage A	Stage B	Stage C	Stage D	Stage E	Stage F	Stage G	
Stage 5:				Adolescent males								Adolescent females				
Aug.	—	—	—	8	40	—	—	48		—	—	—	5	—	—	5
Sept.	—	—	—	2	5	10	—	17	—	—	—	—	1	—	—	1
Oct.	—	—	—	—	10	3	1	14	—	—	—	—	20	3	2	25
Nov.	—	—	—	4	7	2	—	13	—	—	—	—	48	12	18	78
Dec.	—	—	—	—	1	3	—	4	—	—	—	1	39	24	50	114
Jan.	—	—	—	4	2	8	—	14	—	—	—	3	4	10	24	41
Feb.	—	—	—	—	5	6	1	12	—	—	—	1	—	2	7	10
Mar.	—	—	—	1	17	1	—	19	—	—	—	1	—	—	—	1
Apr.	—	—	—	—	7	35	—	42	—	—	—	—	—	—	—	—
May	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
June	—	—	—	—	1	—	—	1	—	—	—	—	—	—	—	—
July	—	—	—	—	2	—	—	2	—	—	—	—	—	—	—	—
Total	—	—	—	19	97	68	2	186	—	—	—	6	117	51	101	275
Stage 6:				Adult males												
Aug.	—	—	—	—	2	10	—	12	—	—	—	—	—	—	—	—
Sept.	—	—	—	—	—	38	1	39	—	—	—	—	—	—	—	—
Oct.	—	—	—	—	—	48	32	80	—	—	—	—	—	—	—	—
Nov.	—	—	—	—	—	2	3	5	—	—	—	—	—	1	2	3
Dec.	—	—	—	—	—	2	5	7	—	—	—	—	3	12	37	52
Jan.	—	—	—	—	—	3	—	3	—	—	—	—	—	15	77	92
Feb.	—	—	—	6	2	6	7	21	—	—	—	6	6	6	27	45
Mar.	—	—	—	—	—	5	9	14	—	—	—	—	2	—	—	2
Apr.	—	—	—	—	—	10	1	11	—	—	—	—	5	1	—	6
May	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
June	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
July	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	—	—	—	6	4	124	58	192	—	—	—	6	16	35	143	200
Stage 7:																
Aug.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Sept.	—	—	—	—	—	—	5	5	—	—	—	—	—	—	—	—
Oct.	—	—	—	—	—	—	67	67	—	—	—	—	—	—	—	—
Nov.	—	—	—	—	—	—	34	34	—	—	—	—	—	—	—	—
Dec.	—	—	—	—	—	—	169	169	—	—	—	—	—	1	3	4
Jan.	—	—	—	—	—	—	130	130	—	—	—	—	—	1	5	6
Feb.	—	—	—	1	—	19	123	143	—	—	—	—	—	9	157	166
Mar.	—	—	—	—	—	—	5	5	—	—	—	—	—	2	127	129
Apr.	—	—	—	—	—	—	4	4	—	—	—	—	3	—	183	186
May	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
June	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
July	—	—	—	—	—	—	1	1	—	—	—	—	—	—	—	—
Total	—	—	—	1	—	19	538	558	—	—	—	—	3	13	475	491

Total adolescent ♂'s	3073	Total adolescent ♀'s	2933
Total adult ♂'s	750	Total adult ♀'s	1273
Total ♂'s	3823	Total ♀'s	4206

N.B. Adolescent total does not include Fraser's 124 specimens.

Table 7. *Growth stages in the female*

Stage	Internal structures	Stage	External structures
1	Primitive condition. Unlobed saddle-shaped ovary. Oviducts clearly visible	A	Thelycum either not visible, or represented only by a straight band across the sternum
2	Ovary becomes lobed. Oviducts become wider	B	Two small coxal outgrowths can be distinguished at each end of sternal band
3	Ovary extends down towards the legs, filling ¼ of thoracic cavity	C	Thelycum half-developed: coxal part larger than sternal part

The smallest specimen at stage 2 occurred in December and measured 20 mm.; the largest measured 48 mm. and occurred in February. The first was at stage A in external development, the second at stage C. The six specimens recorded at stage E measured from 38 to 42 mm. Most of these adolescents, however, were at stage B: 679 specimens were examined and it was found that 157 were at stage A, 346 at stage B, 138 at stage C, 32 at stage D and 6 at stage E. The average length varied from 29 mm. in August through 25 mm. in November to 38 mm. in March, falling to 36 mm. in June.

Of stage 3, 458 specimens were examined. Only two of these were external at stage A; of the rest, 130 were at stage B, 158 at stage C, 146 at stage D and 22 at stage E. The average monthly length varied from 35 mm. in August to 43 mm. in March, falling again in April to 40 mm. and rising once more to 41 mm. in May and June. Great variation in the individual length of the specimens is met with again and, as in stages 1 and 2, the largest measurements approach the average lengths of the young adults very closely, showing that in the female adolescents, as in the male, size is no reliable criterion of development. The smallest specimen was recorded in October: it measured 22 mm. and was at stage C externally. The largest specimens occurred in February and June: they measured 49 mm. and were at stages C and E respectively.

The females now approach maturity. At the next stage (4), the eggs become measurable although the ovary is only half-grown, and in some specimens spermatophores are found in the thelycum, showing that externally these females are fully mature. I regard stage 3, therefore, as marking the end of the period of adolescence in the female.

ADULT KRILL

MATURE MALES

There are two adult stages in the male, stages 6 and 7. In both, spermatophores are to be found in the ejaculatory ducts, but in specimens at stage 6, the spermatophores are not perfectly formed, whereas when stage 7 is reached, there are fully formed spermatophores in both the ejaculatory ducts and in the spermatophore sacs. Two adult external stages in the development of the copulatory organs can also be distinguished. These stages are tabulated below; they correspond to stages 2, 3 and 4 of Ruud.

Table 8. *Growth stages in adult males*

Stage	Internal structures	Stage	External structures
6	Coiling occurs on vas deferens in region of anterior flexure. Imperfect spermatophores in the ejaculatory duct	F	Terminal process of inner lobe reaches to the tip of the median lobe
7	Fully adult condition. Ripe spermatophores in the ejaculatory ducts and in the spermatophore sacs	G	Fully adult condition. Proximal process develops a blade-like expansion at its tip

The average monthly length of stage 6 ranged from 44 mm. in August, through 41 mm. in November, to 54 mm. in February, falling again to 52 and 51 mm. in March and April. Between May and August, no specimens at this stage were found. The smallest specimen, measuring 35 mm. occurred in November, and the largest specimen measuring 64 mm. in February. The November specimen was at stage G externally, and the February specimen was at stage F. In all, 192 specimens were examined, 6 being at stage D, 4 at stage E, 124 at stage F and 58 at stage G.

No fully adult specimens at stage 7 were found in May, June and August, and only one specimen was found in July. The average monthly length varied from 54 mm. in September, through 44 and 45 mm. in October and November to 52 mm. in February, March and April. The smallest specimens, each measuring 35 mm., occurred in October and December, the largest specimen measuring 60 mm. in February; all were at stage G externally. The majority of specimens (538) were fully developed externally, but in 20 males growth of the copulatory organs was not complete, 19 being at stage F and 1 at stage D.

MATURE FEMALES

I have classed all females in which the eggs are of measurable size as mature, i.e. likely to spawn within the next 2 or 3 months.

The eggs become large enough to be measured when the ovary fills about half of the thoracic cavity (stage 4). The thelycum, though not necessarily very heavily chitinized as yet, has assumed the adult shape, and is ready to hold the spermatophores, when they are transferred by the male.

Table 9. *Growth stages in adult females*

Stage	Internal structures	Stage	External structures
4	Ovary fills ½ thoracic cavity. Eggs 0·05–0·12 mm. in diameter	A	Thelycum of adult shape, but not heavily chitinized
5	Ovary fills ¾ thoracity cavity. Eggs 0·13–0·24 mm. in diameter	E	Thelycum full grown and well chitinized
6	Ovary fills thoracic cavity. Eggs 0·25–0·48 mm. in diameter	F	Spermatophores in the thelycum: spermatophores full
7A	Ovary gravid or nearly so. Eggs 0·49–0·70 mm. in diameter	G	Spermatophores in thelycum: spermatophores empty, thelycum full
7B	Ovary primitive again. Eggs spawned	H	Spermatophores torn away—thelycum empty again

In stage 4 of the 307 specimens examined, 55 were externally at stage D, 246 were at stage E, 3 were at stage F and 3 were at stage G. The majority had, therefore, fully mature though unfertilized thelyca. In six of the specimens, those at stages F and G, copulation had taken place, and the females were carrying full or empty spermatophores. The average monthly length varied from 39 mm. in August through 31 mm. in November to 46 mm. in March, falling again in April to 42 mm. No records were obtained in February, May, June or July. The smallest specimen measuring 27 mm. occurred in November: it was externally at stage D. The largest specimen of 55 mm. occurred in September and was at stage F.

By the time stage 5 is reached, the eggs are growing rapidly, and consequently the ovary is beginning to fill up the thoracic cavity. Externally, 117 specimens were at stage E, but the majority carried spermatophores, 51 being at stage F and 101 at stage G. One large specimen measuring 43 mm. was at stage D, whereas the smallest specimen recorded, measuring 30 mm., was at stage G, and the largest specimen of all, measuring 58 mm., was at stage F. The average monthly length varied from 46 mm. in August, through 43 mm. in November and 42 mm. in January back to 46 mm. in February. Only one specimen occurred in March, and no records at all were obtained in April, May, June or July. Stages 4 and 5 correspond to Ruud's stage I.

Stages 6, 7A and 7B may be regarded as covering the fully adult condition in the female and are comparable with stages 2, 3 and 4 of Ruud. The three corresponding stages of external development, F, G and H, show whether copulation has just taken place, or whether it occurred some time ago, and lastly whether the female has spawned, although this is also readily seen from her altered shape. When the spermatophores have been recently implanted in the thelycum, they still contain the sperm-mass (stage F), but after a while this makes its way into the thelycum, leaving the spermatophores empty (stage G). When the eggs are being laid, the spermatophores become loosened and break away from their attachment, so that females which have shed their eggs, generally have empty thelyca (stage H).

Stages 7A and 7B, comprising gravid females and those which have spawned, have been combined together as stage 7 in all analyses of the catch, and in the tables of minimum and maximum length, and in the average length estimations. This has been done for two reasons: in the first place, the number of gravid females (i.e. females at stage 7A) obtained was very small, and in the second place, combining stages 7A and 7B makes it easier to compare the adult females with the adult males. The external stages G and H have been treated similarly. But in order to describe the life history as fully as possible, I have, where necessary, analysed the catch of adult females into the two groups of gravid and spawned.

Out of 200 specimens at stage 6, 6 were at stage D, 16 at stage E, 35 at stage F and 143 at stage G. The smallest specimen, measuring 32 mm., was at stage E; the largest, measuring 60 mm., was at stage G. No specimens at stage 6 occurred in May, June, July, August, September or October. The monthly average length varied between 47 mm. in November through 50 mm. in January and February to 47 mm. in April.

Stages 7A and 7B were represented by 491 specimens, of which 57 were gravid, i.e. at stage 7A, and 434 had spawned, i.e. they were at stage 7B. The time of their occurrence ranged from December to April. The smallest specimen, measuring 41 mm., was found at the end of the season; the largest, measuring 64 mm., in February; both were at stage G. The average monthly length decreased from 57 mm. in December to 47 mm. in April.

Table 10. *Occurrence of gravid and spawned females*

Month	Stage 7A (gravid females)				Stage 7B (spawned females)			
	Total	Stage E	Stage F	Stage G	Total	Stage F	Stage G	Stage H
Dec.	4	—	1	3	—	—	—	—
Jan.	2	—	1	1	4	1	3	—
Feb.	48	—	4	44	118	5	86	27
Mar.	—	—	—	—	129	2	66	61
Apr.	3	3	—	—	183	—	2	181
Total	57	3	6	48	434	8	157	269

Analysis of the total catch of these stages shows that the majority of gravid females (48) occurred in February, and that all except four of the spawned females occurred in February, March and April. Attention has already beeen drawn to the scarcity of the gravid stage. Of the 57 specimens obtained, 40 of the large catch in February were taken from deep nets (250–100 m., 750–500 m.); 3 of the remaining 17 specimens occurred in the surface layer (0–5 m.) and 14 at depths varying between 137 and 0 m. In the catches examined, the marked failure to take gravid females at the surface in any number seems to point to deep spawning. The euphausian egg contains a large quantity of yolk, sufficient to feed the young larva for some little time after hatching, and the external food supply is therefore not of immediate importance to the larva when it first leaves the egg. Presumably, this quantity of yolk makes the egg heavy, for Fraser found that the bulk of the eggs and early larval stages occur at depths below 250 m. Evidence from later commissions of the R.R.S. 'Discovery II' confirms this. Fraser suggested that the eggs become concentrated in basins on the submarine ridges, where the homogeneous water column provides the uniformity of temperature and density necessary for their development. A large catch of 95 gravid females in a vertical net, fished between 250 and 100 m., in February 1930 off South Georgia rather confirms this idea. The vertical 70 cm. net is small and usually catches very few fully grown specimens of *E. superba*. The occurrence of 95 in one haul is exceptional and suggests that the net passed through a dense swarm of them, which might well account for a concentration of eggs. Some of the females in this particular catch subsequently spawned in the ship's laboratory. The great increase in size of the ovary, when the females become fully gravid, may affect their specific gravity, and this may account for their presence in the deeper layers and their absence from the surface nets. In the most recent analyses made on board ship, so-called gravid females were obtained at depths varying between 1000 m. and the surface, but the majority, however, occurred in the 0–5 m. layer. These females may not have been fully gravid: measurements of the eggs in the ovaries could not be systematically attempted in the ship's laboratory, and it is possible that females have been classed as gravid which more properly belong to stage 6. On the other hand, if these analyses are correct, the depths at which gravid females are found extend over a very wide range. This problem really depends for its solution on a discussion of the factors influencing the general distribution of *E. superba*, and is rather outside the scope of this paper.

Comparison of measurements of length with stages of development shows clearly that undue importance must not be attached to size as an indication of maturity. The adolescent class contains specimens, which judged by length alone would be regarded as fully adult, but which on internal evidence are far from mature. The smallest specimens in the adult class, on the other hand, might well be regarded as being still adolescent.

It is interesting to note that although external and internal development do not necessarily keep pace with one another, there is a very fair degree of coincidence of development in the majority of cases. Thus most specimens of stage 1 are also at stage A, those at stage 2 are also at stage B, and so on (Table 6). I would again emphasize the fact that the developmental stages are clearly defined: there is no difficulty in determining to which stage a specimen belongs, so that evidence based on internal and external anatomy, though laborious to acquire, is reliable.

PAIRING

The first records of fully adult males were obtained in September, when five specimens were found. By October they appeared in larger numbers, and in this month the first females carrying spermatophores in the thelycum were noticed. These six females were not yet gravid, but were at stages 4 and 5, the eggs being still in course of development. Pairing evidently takes place as soon as the females have a fully developed thelycum, and it is generally possible to determine whether or not it has occurred recently, because shortly after the spermatophores have been implanted, the sperm-mass passes into the thelycum, leaving the spermatophores empty. The following table shows that of 556 females carrying spermatophores, only 102 were full, showing that the migration of the sperm-mass into the thelycum must be a rapid process.

Table 11. *Number of females with spermatophores*

Month	No. of ♀'s	No. of ♀'s with spermatophores		
		Full	Empty	Torn away
Oct.	6	4	2	—
Nov.	33	13	20	—
Dec.	128	37	91	—
Jan.	135	27	107	1
Feb.	208	17	164	27
Mar.	130	3	68	59
Apr.	184	1	2	181
Total	824	102	454	268
		556		

As a general rule, two spermatophores are found on each female, two being the number implanted at each successful pairing, one from the right and one from the left ejaculatory duct of the male. Sometimes, 4, 6 or 8 spermatophores occur, or 3, 5 or 7 may be found complete, with one broken stalk attached as well. These are presumably cases of multiple pairing. I have seen as many as 6 empty spermatophores on one specimen, but more often 2 or 4 will be full, as the thelycum is not large enough to contain all the sperm-mass. Faulty implantation hardly ever occurs; only one female was found with spermatophores attached elsewhere than in the thelycum. This specimen carried 4 spermatophores, two fixed normally and empty, and two, full, on the base of the last right thoracic appendage.

From December onwards to April, the majority of adult females have paired, as well as quite a number of those nearly adult. The peak season comes in February, when the greatest number was found to occur.

SPAWNING

Spawning takes place when the eggs in the ovary have reached an average diameter of 0·55–0·60 mm. It would appear that the eggs take about four months to reach maturity.

Ruud distinguished three stages in the development of the egg, based on measurements of the egg diameter: stage 1, diameter 0·10–0·25 mm.; stage 2, diameter 0·26–0·50 mm. and stage 3, diameter 0·51–0·70 mm. When stage 3 was reached, the eggs were spawned. I have measured the eggs from 1273 females and I obtained a slightly greater size range, with diameters lying between 0·05 and 0·70 mm. I first analysed the egg measurements from females caught in one season and in one area; presumably they had all matured under the same conditions. It must not be supposed that all the eggs in one ovary are of the same size. Great variation occurs, so I selected the smallest and the largest for measurement and then worked out the mean diameter. As the southern summer advanced, the monthly mean diameter in this one season was found to increase from 0·08 mm. in October, through 0·19 mm. in November and 0·32 mm. in December to 0·60 mm. in January, when the first females which had spawned were also found.

Table 12. *Average diameter in mm. of eggs per month*

Month	Av. diam. of total no. of eggs	Analysis of eggs measured											
		Class 1 (stage 4)			Class 2 (stage 5)			Class 3 (stage 6)			Class 4 (stage 7A)		
		Av. diam.	No. of ♀	%	Av. diam.	No. of ♀	%	Av. diam.	No. of ♀	%	Av. diam.	No. of ♀	%
Aug.	0·09	0·07	31	86	0·20	5	14	—	—	—	—	—	—
Sept.	0·08	0·08	33	97	0·14	1	3	—	—	—	—	—	—
Oct.	0·09	0·08	175	88	0·16	25	12	—	—	—	—	—	—
Nov.	0·15	0·09	15	16	0·16	78	81	0·33	3	3	—	—	—
Dec.	0·23	0·10	12	7	0·19	114	63	0·33	52	29	0·50	4	1
Jan.	0·32	0·09	3	2	0·21	41	29	0·36	92	65	0·50	2	1
Feb.	0·46	—	—	—	0·20	10	5	0·40	45	20	0·57	48	22
Mar.	0·09	0·05	18	12	0·14	1	1	0·40	2	1	—	—	—
Apr.	0·05 0·48	0·05	20	9	—	—	—	0·45	6	3	0·53	3	2
May*													
June*													
July*													

* No ♀'s with measurable eggs.

Table 12 (*cont.*)

Month	No. of ♀'s examined				
	With eggs		Spawned		Grand total
	No. of ♀	%	No. of ♀	%	No. of ♀
Aug.	36	100	—	—	36
Sept.	34	100	—		34
Oct.	200	100	—		200
Nov.	96	100	—		96
Dec.	182	100	—		182
Jan.	138	97	4	3	142
Feb.	103	47	118	53	221
Mar.	21	14	129	86	150
Apr.	29	14	183	86	212
May					
June					
July					
Total	839		434		1273

Using these figures as a guide, I then analysed the egg measurements from all the available material (839 females),[1] and I found that the eggs could be conveniently classified into four size groups, these groups being used to differentiate the four internal stages in the adult females, stages 4–7. The first group includes eggs measuring between 0·05 and 0·12 mm., with a mean diameter at 0·08 mm. (class 1); the second, eggs measuring between 0·13 and 0·24 mm., with a mean diameter at 0·18 mm. (class 2); the third, eggs measuring between 0·25 and 0·48 mm., with a mean diameter at 0·36 mm. (class 3); and the fourth, eggs measuring between 0·49 and 0·70 mm., with a mean diameter at 0·60 mm. (class 4), at which size the females are gravid and spawning occurs.

The analysis of these egg measurements, set out in Table 12, shows that, at first, development is slow, but that, as the season advances, a steady rate of growth ensures that the eggs approximately double their size each month, and take about four months to reach maturity.

The first measurable eggs occurred in females taken in August, and the majority of eggs in August, September and October were in class 1. In November, class 2 appeared in larger numbers and was at a maximum in December. Class 3 appeared for the first time in any quantity in December and was at a maximum in January. Class 4 was at a maximum in February, and in this month and in March and April, the bulk of the females had spawned.

It will be noticed that in March the mean diameter of the eggs has dropped to the same figure as in August and October, the majority of the females having spawned and those with measurable eggs being mostly in class 1. Again, in April, apart from the females which have spawned, there is a range of small eggs. It is possible that these eggs never mature. I have found no females with measurable eggs during the winter months of May, June and July, nor any full adults which have spawned. This may be due either to the sparse material from this time of the year, or else to the fact that the adults do not survive the winter. One particularly striking fact emerges from this analysis of egg measurements: class 4 containing gravid females is represented by very small numbers. The problem of the depth at which spawning takes place has already been discussed, as having a possible bearing on the absence of gravid females from the catch.

The evidence from these egg measurements points to a spawning season extending from January to April, an increasing number of females having laid their eggs as the season advances. But if the

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[1] These measurements are given in full in Table 20 in the appendix.

records of the occurrence of eggs are also taken into account, spawning begins a month or two earlier. Fraser found eggs in the plankton from mid-November to March, and with this additional evidence, it would therefore appear that *E. superba* lays its eggs over a period of $5\frac{1}{2}$ months.

AVERAGE GROWTH RATE

There are two ways of working out the growth rate of *E. superba*: (i) by investigating the growth of the developmental stages, and (2) by investigating the growth of the adolescent and adult population as a whole.

(1) *Growth of the developmental stages.* By the first method, the total catch each month was sexed, measured and divided into the seven growth stages, males and females of course being grouped separately. These measurements are set out in detail in the appendix. Length frequency tables were made for each stage and the average monthly lengths of the stages were calculated. The average length of each stage for the whole year was also worked out (see Table 5, p. 110).

These monthly and yearly averages for males and females are shown graphically in Fig. 1. There is a fair degree of correspondence between the lengths of the sexes at each stage, though on the whole the males tend to be larger and grow more rapidly than the females. The growth of the females is slower and steadier, but the same average length is reached in the final adult stage. The fall which occurs in many of the curves in October and November, following a rise in September, may be due to the stock being replenished, as the spring goes on, by a number of smaller specimens, whose growth has been delayed by winter conditions. The general rise to a maximum in February and March, on the other hand, occurs during the period of optimum conditions of food and temperature.

In both males and females, there is sometimes considerable overlap between the average lengths of the stages. This is seen in Fig. 1 in which these average lengths are superimposed on one another. Size is again shown to be an unreliable criterion of development, a point which has already been much stressed.

In order to find out how long *E. superba* takes to grow to maturity, I have worked out the frequency of occurrence of the developmental stages expressed as a percentage of the catch each month. Table 13 A gives the actual figures[1] and Table 13 B shows the months in which eggs, adolescents and adults are at a maximum.

Fraser's work has shown that the spawning season is a long one. His results indicate that the "greatest production of eggs is in November-December", when two large catches were recorded. But he points out that once the eggs have been spawned, there are so many factors influencing their dispersal, that a rather distorted impression of their abundance may easily be obtained, if it is based on records of egg catches alone. The occurrence of gravid and spawned females gives a more reliable picture. My results show that these are at a maximum in February, March and April, and it seems reasonable to suppose that this will also be the period for the occurrence of the majority of the eggs. Rough analyses made on board the R.R.S. 'Discovery II' during the ship's last two commissions indicate that this maximum for gravid females and eggs is met with a month earlier, i.e. in January, and extends through February to March. Annual variation may account for this, just as an early southern summer is probably the reason for the large catches of eggs recorded by Fraser in November 1929. My results were obtained by examining material from many seasons and localities, and may therefore be regarded as being characteristic of the average catch in average circumstances.

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[1] In the totals of stage I, I have included the records of adolescents from Fraser's paper. He examined 124 young adolescents, and their measurements are given in Table 14. The majority of the lengths lie between 13 and 22 mm., and the specimens can therefore be regarded as all belonging to stage I. Males and females occur in the catch in approximately equal proportions, so I have incorporated these lengths in the totals for stage 1 in both sexes.

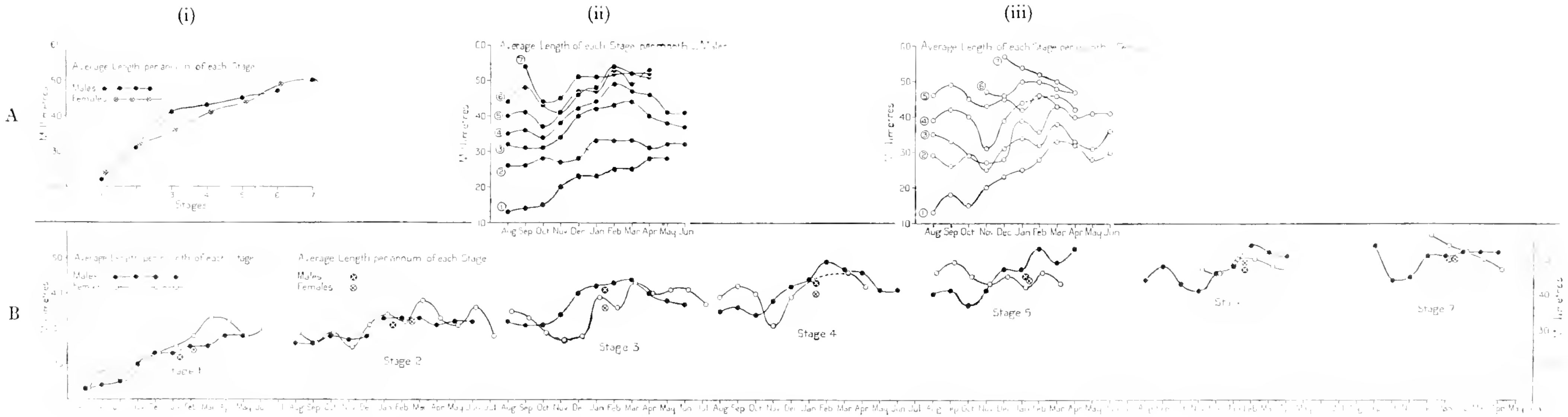

Fig. 1. A (i) Average length per annum of each stage.
(ii) Average length of each stage per month: males.
(iii) ,, ,, ,, ,, : females.

B Composite graph comprising A (i), (ii) and (iii), showing general increase in length from stage 1 to stage 7.

Table 13 A. *Percentage frequency of occurrence per month of developmental stages*

Stage	Aug. Total	Aug. %	Sept. Total	Sept. %	Oct. Total	Oct. %	Nov. Total	Nov. %	Dec. Total	Dec. %	Jan. Total	Jan. %	Feb. Total	Feb. %	Mar. Total	Mar. %	Apr. Total	Apr. %	May Total	May %	June Total	June %	July Total	July %	Totals*
													Males												
1	19	11	19	18	267	53	236	66	301	49	204	47	192	20	63	18	25	7	9	22			—		
2	37	21	17	16	35	7	40	11	82	13	41	9	316	34	87	25	115	30	21	52	4	10			
3	24	14	3	3	23	5	3	1	23	4	27	6	204	22	120	34	125	33	7	18	10	26	1	20	
4	37	21	4	4	17	3	24	7	27	4	18	4	54	6	41	12	61	16	3	8	24	62	1	20	
5	48	27	17	16	14	3	13	4	4	1	14	3	12	1	19	5	42	11		—	1	2	2	40	
6	12	6	39	38	80	16	5	1	7	1	3	1	21	2	14	4	11	3	—	—		—	—	—	
7		—	5	5	67	13	34	10	169	28	130	30	143	15	5	1	4	1		—	—	—	1	20	
Total	177		104		503		355		613		437		942		349		383		40		39		5		3947
													Females												
1	28	12	30	34	287	52	267	69	342	64	245	62	232	26	275	49	188	36	22	36	4	4		—	
2	66	28	17	20	15	3	18	5	8	2	5	1	304	35	110	20	71	13	34	54	28	30	3	27	
3	110	46	4	5	54	10	8	2	1	0	2	1	124	14	30	5	50	10	6	10	61	66	8	73	
4	31	12	33	40	175	31	15	3	12	2	3	1	—	—	18	3	20	4	—	—	—			—	
5	5	2	1	1	25	4	78	20	114	21	41	10	10	2	1	—		—							
6	—	—	—	—	—	—	3	1	52	10	92	23	45	4	2	—	6	1							
7		—	—	—		—	—	—	4	1	6	2	166	19	129	23	186	36	—						
Total	240		85		556		389		533		394		881		565		521		62		93		11		4330

* Totals include Fraser's adolescents (124).

Table 13 B. *Maximum frequency of occurrence of eggs and developmental stages*

Stage	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.
													Males														
Eggs	×	×	×	.	.	.	.	.	.	.	.	.	×	×	×	.	.	.	.	.	.	.	.	.	×	×	×
1	.	.	.	.	.	.	.	.	×	×	×	×	.	.	.	.	.	.	.	.	×	×	×	×	.	.	.
2	×	×	×	×	.	.	.	.	.	.	.	.	×	×	×	×	.	.	.	.	.	.	.	.	×	×	×
3	×	×	×	—	×	.	.	.	.	.	.	.	×	×	×	—	×	.	.	.	.	.	.	.	×	×	×
4	.	.	.	.	×	—	×	.	.	.	.	.	.	.	.	.	×	—	×	.	.	.	.	.	.	.	.
5	.	.	.	.	.	.	×	×	.	.	.	.	.	.	.	.	.	.	×	×	.	.	.	.	.	.	.
6	.	.	.	.	.	.	.	×	×	.	.	.	.	.	.	.	.	.	.	×	×	.	.	.	.	.	.
7	×	.	.	.	.	.	.	.	.	×	×	×	×	.	.	.	.	.	.	.	.	×	×	×	.	.	.
													Females														
Eggs	×	×	×	.	.	.	.	.	.	.	.	.	×	×	×	.	.	.	.	.	.	.	.	.	×	×	×
1	—	×	.	.	.	.	.	.	×	×	×	×	—	×	.	.	.	.	.	.	×	×	×	×	—	×	.
2	×	×	—	×	×	—	×	.	.	.	.	.	×	×	—	×	×	—	×	.	.	.	.	.	.	×	—
3	.	.	.	.	×	×	×	.	.	.	.	.	.	.	.	.	×	×	×	.	.	.	.	.	.	.	.
4	.	.	.	.	.	.	.	×	×	.	.	.	.	.	.	.	.	.	.	×	×	.	.	.	.	.	.
5	.	.	.	.	.	.	.	.	.	×	×	.	.	.	.	.	.	.	.	.	.	×	×	.	.	.	.
6	.	.	.	.	.	.	.	.	.	.	×	×	.	.	.	.	.	.	.	.	.	.	×	×	.	.	.
7	×	×	×	.	.	.	.	.	.	.	.	.	×	×	×	.	.	.	.	.	.	.	.	.	×	×	×

Table 14. *Adolescent lengths: from Fraser's report*

Length in mm.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.
12	5	—	—	—	—	—	—
13	7	3	2	—	—		
14	1	5	7	4	—	—	
15	—	3	9	—	—	—	
16	—	1	13	8	—	—	
17		—	1	15	—	—	—
18	—	—	1	13	—	—	—
19	1	—	—	5	1	1	—
20	—	—	—	2	1	1	
21	—	—	—	5	1	—	—
22	—	—	—	2	1	1	—
23	—	—	—	—	—	—	1
24	—	—	—	—	—	1	—
25	—	—	—	—	—	—	1
26	—	—	—	—	—	—	—
27	—	—	—	—	—	—	—
28	—	—	—	—	—	—	—
29	—	—	—	—	—	1	—
Total	14	12	33	54	4	5	2

NB. Measurements approximate to nearest whole number.

Table 15. *Analysis of the adult female catch per month from later commissions (rough analysis)*

Month	Stage 6		Stage 7 A (gravid)		Stage 7 B (spawned)		Total ♀
	No. of ♀	%	No. of ♀	%	No. of ♀	%	No. of ♀
Oct.	1	100	—	—	—	—	1
Nov.	—	—	2	100	—	—	2
Dec.	10	100	—	—	—	—	10
Jan.	5	1	609	98	2	1	616
Feb.	13	32	13	32	15	36	41
Mar.	12	8	50	35	83	57	145
Apr.	—	—	—	—	1	100	1

Fraser has established that growth from the egg to the 1st adolescent stage occupies approximately 7–9 months. On this basis, if the eggs are most often met with in February, March and April, the maximum occurrence of stage 1 should be in October, November and December. It is significant that these are just the months when this maximum is encountered, with an extension into January in the case of the males, and into March in the case of the slower growing females (Table 13 A and B).

The rest of the period of growth from stage 1 to maturity occupies another 12–16 months in the males and 12–18 in the females. Ruud showed that the life cycle of *E. superba* occupied at least two years. He drew attention to the two classes of krill recognized by the whalers as "blue whale" and "fin whale" krill respectively, and diagnosed them as representing the two age groups, adolescent and adult. But owing to lack of material, and not having devised a method of gauging the stage of development of the adolescent males and females, the growth curve which he figures is too steep, and does not give an accurate idea of the growth rate throughout the whole of the growth period.

Ruud suggested that after pairing and spawning the adults died off. I think this is very likely, for although at the end of April I found females, which had spawned and were feeding actively (a thing they are unable to do while gravid), no fully adult females or males were found between May and October. This may of course be due to lack of material, which in all commissions of the R.R.S.

'Discovery II' has been scarce at this time of the year owing to the difficulty of fishing nets in the prevailing weather and ice conditions, but adolescents have been obtained throughout the year, and it is the half-grown specimens belonging to stages 3, 4 and 5, which are predominant during the winter months. Young adults do not appear until September and full adults not before October. On the evidence available, therefore, it is reasonable to conclude that adults do not exist in the catch after the pairing and spawning season is over, because they have died out.

It would be interesting if the time of duration of each stage could be established with some certainty, but this is not so easy. Growth in the female is slower than in the male, and it seems likely that the earlier stages anyhow take longer to pass through. There are indications in the table of maximum frequency of occurrence of the stages (Table 13, p. 122) that each stage lasts 2 months in the male and 2½ months in the female, and on this basis it is possible to work out the months in which each stage should be theoretically at a maximum. Supposing that: (1) the spawning period extends from November to April, i.e. 5½ months, (2) the adolescents first appear in August, i.e. 9 months later, (3) the maximum spawning period occurs in February, March and April, and (4) each stage lasts 2 months in males and 2½ months in females, then, *in theory*, the maximum occurrence of each stage should be as in Table 16:

Table 16

Eggs	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Stage 6	Stage 7
Male:							
Nov. eggs	End of Aug.	Oct.	Dec.	Feb.	Apr.	June	Aug.
Dec. eggs	End of Sept.	Nov.	Jan.	Mar.	May	July	Sept.
Jan. eggs	End of *Oct.*	Dec.	*Feb.*	Apr.	June	Aug.	*Oct.*
Feb. eggs	End of *Nov.*	Jan.	*Mar.*	May	July	*Sept.*	*Nov.*
Mar. eggs	End of *Dec.*	*Feb.*	*Apr.*	*June*	*Aug.*	*Oct.*	*Dec.*
Apr. eggs	End of *Jan.*	*Mar.*	*May*	July	*Sept.*	Nov.	*Jan.*
	—	—	*June*	*Aug.*	—	—	*Feb.*
Female:							
Nov. eggs	End of Aug.	Beg. of Nov.	End of Jan.	Beg. of Apr.	End of June	Beg. of Sept.	End of Nov.
Dec. eggs	End of Sept.	Beg. of Dec.	End of Feb.	Beg. of May	End of July	Beg. of Oct.	End of Dec.
Jan. eggs	End of *Oct.*	Beg. of Jan.	End of Mar.	Beg. of June	End of Aug.	Beg. of Nov.	End of Jan.
Feb. eggs	End of *Nov.*	Beg. of *Feb.*	End of Apr.	Beg. of July	End of Sept.	Beg. of *Dec.*	End of *Feb.*
Mar. eggs	End of *Dec.*	Beg. of *Mar.*	End of May	Beg. of Aug.	End of Oct.	Beg. of *Jan.*	End of *Mar.*
Apr. eggs	End of *Jan.*	Beg. of Apr.	End of *June*	Beg. of *Sept.*	End of *Nov.*	Beg. of Feb.	End of *Apr.*
	—	Beg. of *May*	End of *July*	Beg. of *Oct.*	End of *Dec.*	—	—
	End of *Mar.*	Beg. of *June*	End of *Aug.*	—	—	—	—
	—	—	—	—	—	—	—
	—	Beg. of *Aug.*	—	—	—	—	—

The months, in which the stages have actually been found to be at a maximum in practice, are already known (Table 13), and have been italicized in, or (where necessary) added to, the above table. There is on the whole a very fair degree of correspondence between expectation and reality, especially when it is remembered that the material used came from very many seasons and localities. It is interesting to note that, in practice, growth is slower during the winter months than it is in theory, the actual maxima occurring later in the season than expected.

Of course the stages overlap one another in occurrence; this is the outcome of the protracted spawning season. Some idea of the extent to which this takes place can be obtained by tracing the growth of the generations arising from eggs spawned in different months. Suppose that the months considered are those in which the eggs are known to be at a maximum, namely February, March and April. We know that these eggs can, under optimum conditions, reach the first adolescent stage in 7 months, though normally they take an average of 8–9 months to do so. In each successive batch of

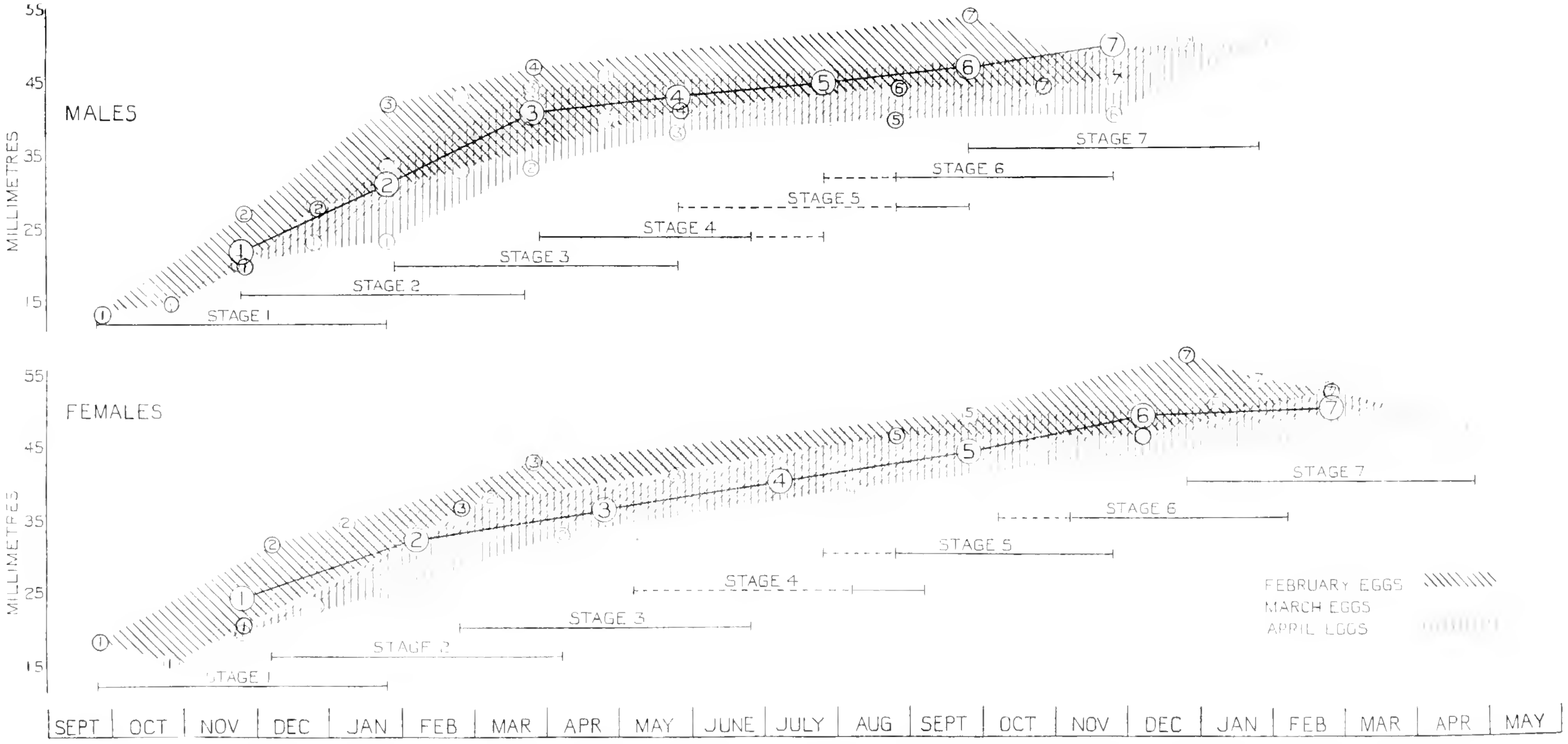

Fig. 2. Diagram showing the growth of the euphausian generations derived from three different batches of eggs, spawned in February, March and April, respectively. The heterogeneous composition of the population at any month of the year is indicated.

eggs, therefore, the distribution in time of each developmental stage may be spread over a period of three months. Thus, eggs spawned in February may become adolescent in the following September, October or November, that is, specimens at stage 1 met with in these months may have originated from eggs laid in February. Similarly, eggs spawned in March may become adolescent in the following October, November or December, or alternatively, specimens at stage 1 in these months may have developed from eggs laid in March and so on.

The months, in which the other developmental stages may be theoretically expected to occur, can also be worked out, by assuming that each stage lasts 2 months in the male and 2½ months in the female. In this way, an explanation of the heterogeneous composition of the euphausian population is obtained, and in Fig. 2 I have attempted to give some idea of this complexity at any given time by a diagrammatic representation of the generations arising from the three batches of eggs, spawned in February, March and April. The average length per month of each stage has been plotted, and the points marking the maximum average values have been joined up, as well as those marking the minimum average values. The space between has been hatched in colour: blue for the generation arising from February eggs, red for March and green for April. The months in which the stages have been calculated to occur, and the values of the average lengths are set out in Table 17. It will be noticed that in the winter months no values are given for stage 5 in the males and stage 4 in the females. In the scanty material available from this time of the year, these stages did not occur, although theoretically they should be present. In the figure the actual period of time, in which each stage appears, is shown by a solid black line, the theoretical period by a broken line.

Table 17

Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Stage 6	Stage 7
Males: time interval: 2 months						
End of Sept. 14 mm.	End of Nov. 27 mm.	End of Jan. 42 mm.	End of Mar. 47 mm.	End of May —	End of July —	End of Sept. 54 mm.
End of Oct. 15 mm.	End of Dec. 28 mm.	End of Feb. 43 mm.	End of Apr. 46 mm.	End of June —	End of Aug. 44 mm.	End of Oct. 44 mm.
End of Nov. 20 mm.	End of Jan. 33 mm.	End of Mar. 44 mm.	End of May 41 mm.	End of July —	End of Sept. 48 mm.	End of Nov. 45 mm.
End of Dec. 23 mm.	End of Feb. 33 mm.	End of Apr. 40 mm.	End of June 41 mm.	End of Aug. 40 mm.	End of Oct. 43 mm.	End of Dec. 51 mm.
End of Jan. 23 mm.	End of Mar. 33 mm.	End of May 38 mm.	End of July —	End of Sept. 41 mm.	End of Nov. 41 mm.	End of Jan. 51 mm.
Females: time interval: 2½ months						
End of Sept. 18 mm.	Beg. of Dec. 31 mm.	End of Feb. 36 mm.	Beg. of May —	End of July —	Beg. of Oct. —	End of Dec. 57 mm.
End of Oct. 15 mm.	Beg. of Jan. 34 mm.	End of Mar. 43 mm.	Beg. of June —	End of Aug. 46 mm.	Beg. of Nov. 47 mm.	End of Jan. 54 mm.
End of Nov. 20 mm.	Beg. of Feb. 32 mm.	End of Apr. 40 mm.	Beg. of July —	End of Sept. 49 mm.	Beg. of Dec. 46 mm.	End of Feb. 52 mm.
End of Dec. 23 mm.	Beg. of Mar. 38 mm.	End of May 41 mm.	Beg. of Aug. 39 mm.	End of Oct. 45 mm.	Beg. of Jan. 50 mm.	End of Mar. 50 mm.
End of Jan. 25 mm.	Beg. of Apr. 33 mm.	End of June 41 mm.	Beg. of Sept. 42 mm.	End of Nov. 43 mm.	Beg. of Feb. 50 mm.	End of Apr. 47 mm.

The fate of early or late spawned eggs can be seen at a glance from the diagram. February eggs, which have reached stage 1 at the beginning of the following season (i.e. September to November) will have grown sufficiently to be at stage 4 or 5 before the winter sets in (i.e. June), and will be mature by October or December of the succeeding spring; they attain rather greater lengths than the later generations. On the other hand, April eggs may not reach stage 1 until the following January, and will not therefore be approaching maturity, that is at stage 5, until the succeeding September, nor will they be fully mature before the January (or April) after that. The overlap of the stages in the three batches of eggs and the resulting mixed composition of the euphausian population is clearly shown. The picture could be made even more complex, if the batches of eggs from every month in the whole spawning season were represented, but I decided not to attempt this, because the diagram would lose in clarity.

(2) *Growth of the euphausian population as a whole.* By the second method mentioned on p. 120, the population was sexed, measured and divided into adolescents and adults, males and females again being treated separately. The average monthly lengths of adolescents and adults were then calculated (Table 18).

Table 18. *Showing average length per month of larval, adolescent and adult* Euphausia superba

Month	Average length per month of larvae and adolescents compiled from Fraser's paper				Average length per month of adolescent and adult males				Average length per month of adolescent and adult females				Month
	Larvae		Adolescents		Adolescents		Adults		Adolescents		Adults		
	Av. length mm.	No. of specimens	Av. length mm.	No. of specimens	Av. length mm.	No. of specimens	Av. length mm.	No. of specimens	Av. length mm.	No. of specimens	Av. length mm.	No. of specimens	
Nov.	1	5	—	—	—	—	—	—	—	—	—	—	Nov.
Dec.	1	5	—	—	—	—	—	—	—	—	—	—	Dec.
Jan.	4	56	—	—	—	—	—	—	—	—	—	—	Jan.
Feb.	4	101	—	—	—	—	—	—	—	—	—	—	Feb.
Mar.	5	182	—	—	—	—	—	—	—	—	—	—	Mar.
Apr.	6	177	—	—	—	—	—	—	—	—	—	—	Apr.
May	8	18	—	—	—	—	—	—	—	—	—	—	May
June	10	3	—	—	—	—	—	—	—	—	—	—	June
July	—	—	—	—	—	—	—	—	—	—	—	—	July
Aug.	10	29	13	14	13	19	—	—	13	28	—	—	Aug.
Sept.	11	27	14	12	14	19	—	—	18	30	—	—	Sept.
Oct.	13	33	15	33	19	356	—	—	18	356	—	—	Oct.
Nov.	13	49	18	54	23	316	—	—	21	293	—	—	Nov.
Dec.	16	1	20	4	26	437	—	—	23	351	—	—	Dec.
Jan.	—	—	23	5	29	304	—	—	25	252	—	—	Jan.
Feb.	—	—	24	2	36	778	—	—	31	660	—	—	Feb.
Mar.	—	—	—	—	38	330	—	—	35	415	—	—	Mar.
Apr.	—	—	—	—	39	368	—	—	34	309	—	—	Apr.
May	—	—	—	—	33	40	—	—	31	62	—	—	May
June	—	—	—	—	39	39	—	—	39	93	—	—	June
July	—	—	—	—	40	4	—	—	35	11	—	—	July
Aug.	—	—	—	—	34	146	44	12	32	176	40	36	Aug.
Sept.	—	—	—	—	34	41	47	44	27	21	42	34	Sept.
Oct.	—	—	—	—	—	—	44	147	—	—	41	200	Oct.
Nov.	—	—	—	—	—	—	45	39	—	—	41	96	Nov.
Dec.	—	—	—	—	—	—	51	176	—	—	45	182	Dec.
Jan.	—	—	—	—	—	—	51	133	—	—	48	142	Jan.
Feb.	—	—	—	—	—	—	52	164	—	—	51	221	Feb.
Mar.	—	—	—	—	—	—	52	19	—	—	50	150	Mar.
Apr.	—	—	—	—	—	—	51	15	—	—	47	212	Apr.
Total		686		124		3197		749*		3057		1273	Total

* 1 adult in July neglected.

Larvae = nauplius to 6th furcilia.
Adolescent males = stages 1–5 (+ Fraser's adolescents).
Adolescent females = stages 1–3 (+ Fraser's adolescents).
Adult males = stages 6–7.
Adult females = stages 4–7.

To obtain a complete growth curve, monthly averages of the larvae must be included. Using Fraser's measurements, I recalculated these averages, which had been originally worked out on a half-monthly basis, and I also made monthly frequency tables of his measurements of young adolescents.

These larval averages show the rate of growth during the first six or seven months, but when the adolescents make their appearance in August, it is not sufficient to work out the average length of *all* adolescents per month. Some selection is necessary, because early in the southern spring, that is, in August, September and October, the overlap of generations brings about the co-existence in the catch of young adolescents of stage 1 with late adolescents of stages 3, 4 and 5 of earlier generations, and the inclusion of these larger adolescents in the calculations gives a wrong idea of the growth rate in these particular months. Later in the season, the population becomes more sharply divided into adolescents and adults, and the question of selection does not arise. I have, therefore, included in the calculations for August, September and October, only the measurements of Fraser's adolescents and of my own specimens at stage 1. In calculating the average lengths of the adults, I have used all specimens which could be expected to mature within the southern summer, that is stage 6 as well as stage 7 in the males, and stages 4–7 in the females.

In Fraser's original graph of larval growth, there is a marked decrease during the winter months, June, July and August. This tends to disappear when his results are combined with mine (Fig. 3), and may have been due, in part, to scarcity of material. I think, too, that the apparent slowing-up of growth during the second winter, in the transition period between adolescence and maturity, can also be partly explained on these grounds, although the colder temperatures and less abundant food almost certainly have some retarding effect upon the growth rate.

Before one year's growth is over, that is, as soon as the adolescents appear in August, it becomes possible to distinguish between males and females, and the curve can therefore be divided into two parts (Fig. 3). The rate of growth in the two sexes is very similar. Although the females are consistently smaller than the males, the two curves follow approximately the same course. The period of adolescence occupies, at a minimum, a whole year and is shorter in the males than in the females. In the males, true adults, carrying fully formed spermatophores, appear for the first time in September. In the females, true adults, fully gravid, appear three months later in December. The total period of growth from the egg to the adult occupies a minimum of twenty-two months in the male, and twenty-five months in the female.

FACTORS INFLUENCING GROWTH RATE

Obviously, the main factor which influences the growth rate of *E. superba* is the supply of food. Hart (1934) writes that this "consists very largely, if not entirely of diatoms and other phytoplankton organisms". He found that the most strongly silicified diatoms could be identified with certainty in the stomach contents, but that those with thinner cell walls were too rapidly digested to be easily recognizable.

In a later paper (1942), Hart discusses the factors which control the production of phytoplankton in the Antarctic zone as a whole. He states that chief among them are the physical influences of "light, the degree of stability of the surface layers and the (interrelated) effects of the pack-ice", and that these three agents are "certainly the prime causes in determining the time of the onset of the main increase" in the abundance of phytoplankton. This time, "falls later in the year as one proceeds southwards", as much as two months elapsing between its occurrence in the northern and the southern regions of the Antarctic zone. However, Hart considers that none of these factors "adequately accounts for the vastly greater richness of the neritic areas as compared with the oceanic regions". Recent work strongly indicates that this is due to minute traces of organic compounds, iron and manganese, derived from the land, which exert a "strongly favourable influence on phytoplankton production". The importance of the pack-ice in this connexion is strongly emphasized. Hart regards it as "giving rise to what might be termed pseudo-coastal conditions at vast distances from land, where neritic species maintained by the ice flourish for short periods when the latter disperses".

All these factors, since they influence the food supply, must have a bearing on the growth rate of *E. superba*, but it is not a simple matter to produce evidence in support of this. Only an unbroken series of observations extending over several seasons and made at short regular time intervals at the same stations would provide reliable data. Unfortunately such a series is not available, the material collected being too scattered and interrupted, so that there are many gaps in the chain of evidence and attempts at correlation are always breaking down.

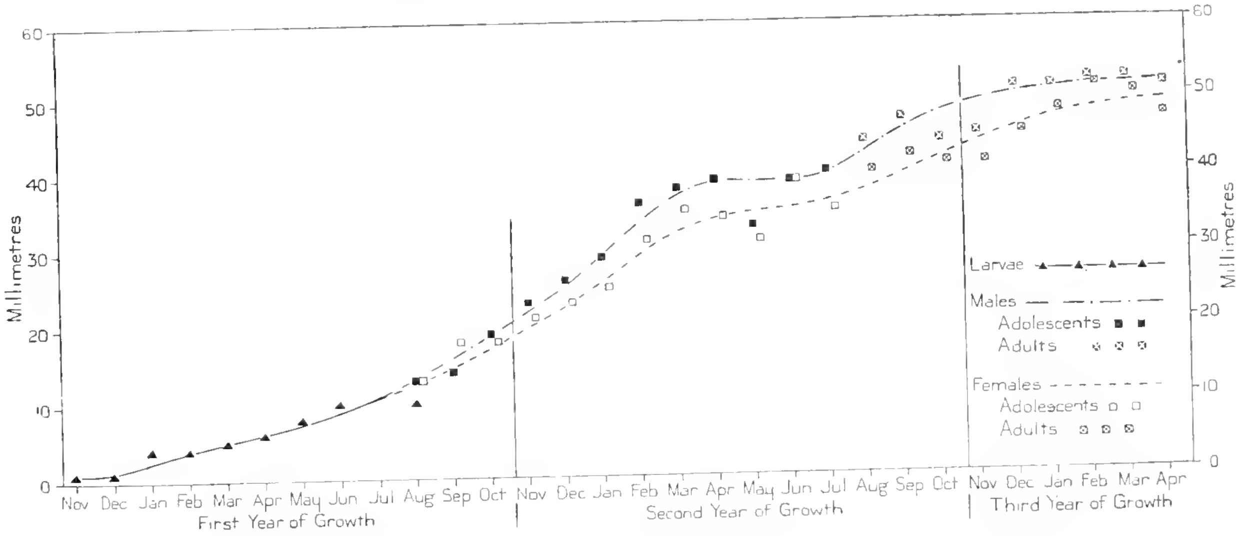

Fig. 3. Growth curve showing average length per month of larvae, adolescents and adults.

As the diatom maximum occurs earlier in the northern region of the Antarctic zone than in the southern, the average development of the northern *E. superba* should be correspondingly more advanced. But Fraser found no clear indication that larval development begins sooner in one area than in another, though he obtained some suggestions that *local* variations in the abundance of food may directly affect the average larval length. He did not feel justified, however, in concluding that, within a restricted area, food was the only factor involved, but decided rather that the effect was the cumulative result of several factors acting locally.

Comparison of the size of larvae, adolescents and adults from the different Antarctic regions does not give a satisfactory result either. This may be due to the fact that length alone is not a reliable criterion of development, but even if the developmental stages are taken into account, the evidence is not more definite. From the material available, it cannot be shown that older adolescents or fully mature adults occur any earlier in the northern Antarctic region than in the southern. But on the other hand, there is evidence to show that those *E. superba*, which are hatched early anywhere within the Antarctic zone, are directly influenced by the abundance of the food supply. Hart points out that the summer decrease in phytoplankton may be due in part to a temporary shortage of silica, and that this is probably brought about to some extent in the oceanic areas, anyhow, by intensive "grazing down by the herbivorous zooplankton". This occurs during and immediately after the period of the spring maximum, in December, January and February. These months coincide with the first half of the spawning season in *E. superba*, and it would appear that those generations hatched early, which are able to benefit fully from the spring maximum, reach greater average lengths than those developing later, when grazing down has brought about a decrease in the food supply. This variation in size has already been mentioned (p. 110), and Fig. 3 shows that it is maintained throughout the life-cycle, these larger adolescents giving rise to the very big adults, which occur at the beginning of the breeding season.

The influence of the spring diatom maximum on the average lengths of the stages is also apparent, though it is perhaps more consistently marked in the males than in the females. If plotted graphically, the average lengths show a fairly rapid rise from October or November to a peak in February or March (Figs. 1 and 3), after which they generally tend to decrease slightly or to remain almost stationary. The period of increase in length corresponds roughly with the time of the phytoplankton maximum, and the succeeding period of slackened growth corresponds with the time of the post-maximal decrease. A similar rise and fall at the same time of the year is seen in the maximum lengths of the stages. The onset of the southern winter is doubtless also a factor which comes into play at this time and influences the rate of growth, for Deacon (1933) has shown that the difference between the summer and winter temperatures of the Antarctic surface water is as much as four degrees.

The other factors mentioned by Hart, light, surface conditions and pack-ice, except in so far as their broad seasonal variations will certainly influence the growth rate, more properly affect the distribution of *E. superba*, and are outside the scope of this paper. This distribution was being worked out by my colleague, J. W. S. Marr, but unfortunately its completion has been interrupted for the time being by the war.

CONCLUSIONS

This investigation extends Fraser's work on the growth of *E. superba* from the egg to the beginning of adolescence, and amplifies Ruud's sketch of a two year life-cycle.

In order to estimate accurately the composition of the euphausian population, a method was devised, by intensive study of the reproductive system, for determining the degree of maturity of each individual. It was found possible to distinguish between males and females immediately the larval state was left behind, and to divide the period of their growth to maturity into 7 stages. This method gives a convenient way of checking deductions based on measurements of length alone, and has shown clearly that individual length is not necessarily a reliable criterion of development, since there is evidence to show that length may be the first thing to be influenced by variations in the factors affecting the rate of growth. Division of the population into growth stages, combined with estimations of the average length of these stages, however, gives a good idea of the life history.

The spawning season, which extends over 5½ months, begins in November or December. Eggs spawned then are probably adolescent by August, and mature about thirteen months later in September and October. The males grow more rapidly than the females, attaining slightly greater average lengths on the whole, and requiring a probable minimum of 22 months to reach maturity, as against 25 months in the female. It seems likely that each state lasts 2 months in the male and 2½ months in the female, though these times are not definitely established as yet, lack of material at certain periods of the year making the evidence too scanty.

Pairing was first found to take place in October, before the females were fully adult. The spermatophores are therefore carried for some time before fertilization can occur, the evidence showing that this is effected externally, while the eggs are being laid. Gravid females are present in surprisingly small numbers. This fact, coupled with Fraser's records of eggs and early larval stages in the deeper water layers, seems to indicate that the females go down deep to spawn. More evidence on this point is needed, before this can be definitely established.

The prolonged spawning season, which is characteristic also of euphausians from the northern hemisphere, gives rise to a very heterogeneous population, the stock being continually replenished by the addition of new generations. Adults were found between the months of August and April, but when the breeding season is over, they appear to die off, being absent from the catch during the autumn and winter months. It should be mentioned, however, that after spawning, females were found in April at the surface feeding actively, a fact which does not suggest lack of vitality, and therefore, since after this month the available material becomes very scanty, their apparent absence may simply be due to lack of evidence, and not to a holocaust consequent on exhaustion after breeding.

The material available is not enough to show a correlation between the appearance of the spring phytoplankton maximum in the different regions of the Antarctic zone and the precosity of development of the euphausian population, but there is evidence to show that generations hatched early in the season anywhere in the zone benefit directly from the abundance of food and the rising temperature of the surface layers, while later generations develop more slowly, partly no doubt because the food supply is becoming reduced by grazing-down, and partly because of the onset of the colder weather.

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APPENDIX

Table 19. *Measurements of all Specimens of* Euphausia superba *examined*

MALES

Date	August 28, 1928	Locality	S. Georgia
St. No.	WS 264	Position	53° 13′·30 S, 34 51′·00 W
Net	N 70 B 97–0 m.	Surface T.	−1·65° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
11	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
12	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
13	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
14	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
22	1	.	.	.	.	.	.	.	1	.	.	.	.	.	1
23	.	4	.	.	.	.	.	4	.	.	.	.	.	.	4
24	.	7	.	.	.	.	.	5	2	.	.	.	.	.	7
25	.	8	.	.	.	.	.	3	5	.	.	.	.	.	8
26	.	3	.	.	.	.	.	2	1	.	.	.	.	.	3
27	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
28	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
30	.	1	2	2	.	.	.	.	2	3	.	.	.	.	5
32	.	.	1	3	.	.	.	.	.	1	3	.	.	.	4
33	.	.	.	2	.	.	.	.	.	.	2	.	.	.	2
34	.	.	1	1	.	.	.	.	.	1	.	1	.	.	2
35	.	.	.	.	5	.	.	.	.	.	.	5	.	.	5
36	.	.	.	.	2	.	.	.	.	.	.	2	.	.	2
37	.	.	.	.	1	.	.	.	.	.	.	1	.	.	1
38	.	.	.	.	1	.	.	.	.	.	.	1	.	.	1
39	.	.	.	.	1	.	.	.	.	.	.	1	.	.	1
41	.	.	.	.	3	1	.	.	.	.	.	3	1	.	4
42	.	.	.	.	.	2	.	.	.	.	.	.	2	.	2
43	.	.	.	.	.	2	.	.	.	.	.	.	2	.	2
45	.	.	.	.	.	1	.	.	.	.	.	.	1	.	1
46	.	.	.	.	.	1	.	.	.	.	.	.	1	.	1
47	.	.	.	.	.	1	.	.	.	.	.	.	1	.	1
51	.	.	.	.	.	1	.	.	.	.	.	.	1	.	1
Total	5	25	4	8	13	9	.	18	13	5	5	14	9	.	64
Av. length	14	25	32	32	37	44	.	22	26	32	32	37	44	.	

Date	August 16, 1938	Locality	S. of Bouvet I.
St. No.	2391	Position	55° 03′·3 S, 00 21′ E
Net	N 100 H 5–0 m. N 100 B 430–225 m. 700–0 m.	Surface T.	−1·32° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
25	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
35	.	.	1	.	1	.	.	.	.	1	.	1	.	.	2
38	.	.	.	.	2	.	.	.	.	.	1	1	.	.	2
42	.	.	.	.	1	.	.	.	.	.	.	1	.	.	1
43	.	.	.	.	1	.	.	.	.	.	.	1	.	.	1
44	.	.	.	.	1	.	.	.	.	.	.	1	.	.	1
47	.	.	.	.	1	.	.	.	.	.	.	1	.	.	1
Total	.	1	1	.	7	.	.	.	1	1	1	6	.	.	9
Av. length	.	25	35	.	41	.	.	.	25	35	38	42	.	.	

Date	August 17, 1938	Locality	S. of Bouvet I.
St. No.	2393	Position	56° 42′·3 S, 00 38′·3 E
Net	N 100 H 5–0 m. N 100 B 128–0 m.	Surface T.	−1·81° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
28	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
30	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
31	.	.	1	.	.	.	.	.	1	.	.	.	.	.	1
32	.	1	1	2	.	.	.	.	1	2	1	.	.	.	4
33	.	.	2	2	.	.	.	.	.	2	2	.	.	.	4
34	.	.	1	.	.	.	.	.	.	1	.	.	.	.	1
35	.	.	.	1	.	.	.	.	.	.	1	.	.	.	1
36	.	.	.	1	.	.	.	.	.	.	1	.	.	.	1
39	.	.	.	.	1	.	.	.	.	.	.	1	.	.	1
45	.	.	.	.	1	.	.	.	.	.	.	1	.	.	1
48	.	.	.	.	1	.	.	.	.	.	.	1	.	.	1
Total	.	3	5	6	3	.	.	.	4	5	5	3	.	.	17
Av. length	.	30	33	34	44	.	.	.	30	33	34	44	.	.	

Date	August 18, 1938	Locality	S.E. of Bouvet I.
St. No.	2396	Position	56° 17′·7 S, 03° 07′·9 E
Net	N 100 B 109–0 m.	Surface T.	−1·65° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
40	.	.	.	.	1	.	.	.	.	.	1	.	.	.	1
42	.	.	.	.	1	.	.	.	.	.	.	1	.	.	1
43	.	.	.	.	1	.	.	.	.	.	.	1	.	.	1
Total	.	.	.	.	3	.	.	.	.	.	1	2	.	.	3
Av. length	.	.	.	.	42	.	.	.	.	.	40	43	.	.	

FEMALES

Date	August 28, 1928	Locality	S. Georgia
St. No.	WS 264	Position	53 13′·30 S, 34 51′·00 W
Net	N 70 B 97–0 m.	Surface T.	−1·65° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
10	2	.	.	.	.	.	.	2	.	.	.	.	.	.	2
11	2	.	.	.	.	.	.	2	.	.	.	.	.	.	2
12	4	.	.	.	.	.	.	4	.	.	.	.	.	.	4
13	4	.	.	.	.	.	.	4	.	.	.	.	.	.	4
14	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
21	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
22	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
24	.	3	.	.	.	.	.	.	2	1	.	.	.	.	3
25	.	10	.	.	.	.	.	.	2	8	.	.	.	.	10
26	.	1	.	.	.	.	.	.	.	1	.	.	.	.	1
27	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
28	.	1	.	.	.	.	.	.	.	1	.	.	.	.	1
29	.	2	.	.	.	.	.	.	1	1	.	.	.	.	2
30	.	2	1	.	.	.	.	.	.	3	.	.	.	.	3
31	.	1	2	.	.	.	.	.	.	3	.	.	.	.	3
32	.	.	1	.	.	.	.	.	.	1	.	.	.	.	1
33	.	.	2	1	.	.	.	.	.	1	2	.	.	.	3
34	.	.	2	2	.	.	.	.	.	.	4	.	.	.	4
35	.	.	2	1	.	.	.	.	.	1	2	.	.	.	3
36	.	.	.	3	.	.	.	.	.	.	3	.	.	.	3
39	.	.	.	3	.	.	.	.	.	.	1	2	.	.	3
40	.	.	.	1	.	.	.	.	.	.	.	1	.	.	1
41	.	.	.	1	.	.	.	.	.	.	1	.	.	.	1
42	.	.	.	.	1	.	.	.	.	.	.	1	.	.	1
43	.	.	.	2	1	.	.	.	.	.	.	3	.	.	3
45	.	.	.	.	2	.	.	.	.	.	.	2	.	.	2
55	.	.	.	.	1	.	.	.	.	.	.	1	.	.	1
Total	13	23	10	14	5	.	.	13	8	21	13	10	.	.	65
Av. length	12	26	33	37	46		.	12	25	28	35	43	.	.	

Date	August 16, 1938	Locality	S. of Bouvet I.
St. No.	2391	Position	55° 03′·3 S, 00° 21′ E
Net	N 100 H 5–0 m. N 100 B 430–225 m. 700–0 m.	Surface T.	−1·32° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
29	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
31	.	.	1	.	.	.	.	.	1	.	.	.	.	.	1
35	.	.	1	.	.	.	.	.	.	1	.	.	.	.	1
36	.	.	2	.	.	.	.	.	.	2	.	.	.	.	2
37	.	.	1	.	.	.	.	.	.	1	.	.	.	.	1
38	.	.	2	.	.	.	.	.	.	1	1	.	.	.	2
39	.	.	1	.	.	.	.	.	.	.	1	.	.	.	1
40	.	.	2	.	.	.	.	.	.	1	1	.	.	.	2
44	.	.	1	.	.	.	.	.	.	.	1	.	.	.	1
45	.	.	1	.	.	.	.	.	.	.	1	.	.	.	1
Total	.	1	12	.	.	.	.	.	2	6	5	.	.	.	13
Av. length	.	29	38	.	.	.	.	.	30	37	41	.	.	.	

Date	August 17, 1938	Locality	S. of Bouvet I.
St. No.	2393	Position	56° 42′·3 S, 00 38′·3 E
Net	N 100 H 5–0 m. N 100 B 128–0 m.	Surface T.	−1·81° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
26	.	1	.	.	.	.	.	1	.	.	.	.	.	.	1
27	.	1	.	.	.	.	.	1	.	.	.	.	.	.	1
28	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
30	.	5	1	.	.	.	.	.	6	.	.	.	.	.	6
31	.	3	.	.	.	.	.	.	1	2	.	.	.	.	3
32	.	.	1	.	.	.	.	.	.	1	.	.	.	.	1
33	.	2	.	.	.	.	.	.	1	1	.	.	.	.	2
34	.	1	1	.	.	.	.	.	2	.	.	.	.	.	2
35	.	1	2	.	.	.	.	.	1	2	.	.	.	.	3
38	.	.	2	.	.	.	.	.	.	.	2	.	.	.	2
39	.	.	1	.	.	.	.	.	.	1	.	.	.	.	1
40	.	.	1	.	.	.	.	.	.	.	1	.	.	.	1
Total	.	15	9	.	.	.	.	2	12	7	3	.	.	.	24
Av. length	.	31	36	.	.	.	.	27	31	34	39	.	.	.	

Date	August 18, 1938	Locality	S.E. of Bouvet I.
St. No.	2396	Position	56 17′·7 S, 03 07′·9 E
Net	N 100 B 109–0 m.	Surface T.	−1·65 C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
40	.	.	.	1	.	.	.	.	.	.	1	.	.	.	1
Total	.	.	.	1	.	.	.	.	.	.	1	.	.	.	1
Av. length	.	.	.	40	.	.	.	.	.	.	40	.	.	.	

MALES

Date August 19, 1938
St. No. 2399
Net N 100 H 5–0 m.
N 100 B {98–0 m. / 300–150 m.
Locality S.E. of Bouvet I.
Position {54° 47'·1 S, 06° 31'·3 E
Surface T. 1·71° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
29	.	2	1	.	.	.	.	.	3	.	.	.	.	.	3
30	.	.	1	.	.	.	.	.	1	.	.	.	.	.	1
32	.	.	1	.	.	.	.	.	.	1	.	.	.	.	1
33	.	.	.	1	.	.	.	.	.	1	.	.	.	.	1
35	.	.	.	3	.	.	.	.	.	.	3	.	.	.	3
36	.	.	.	2	.	.	.	.	.	2	.	.	.	.	2
37	.	.	.	3	1	.	.	.	.	1	3	.	.	.	4
39	.	.	.	.	2	.	.	.	.	.	1	1	.	.	2
40	.	.	.	.	1	.	.	.	.	.	.	1	.	.	1
43	.	.	.	.	1	.	.	.	.	.	.	1	.	.	1
Total	.	2	3	9	5	.	.	.	4	5	7	3	.	.	19
Av. length	.	29	31	36	40	.	.	.	29	35	36	41	.	.	

Date August 22, 1938
St. No. 2408
Net N 100 H 5–0 m.
N 100 B} 108–0 m.
N 70 B }
Locality E. of Bouvet I.
Position {54° 52'·45 S, 16° 22'·2 E
Surface T. −1·21° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
30	.	1	2	.	.	.	.	.	3	.	.	.	.	.	3
31	.	.	.	1	.	.	.	.	.	1	.	.	.	.	1
32	.	.	1	.	.	.	.	.	.	1	.	.	.	.	1
33	.	.	.	2	.	.	.	.	.	2	.	.	.	.	2
34	.	.	1	2	.	.	.	.	.	2	1	.	.	.	3
35	.	.	.	3	.	.	.	.	.	1	2	.	.	.	3
36	.	.	.	1	.	.	.	.	.	.	1	.	.	.	1
37	.	.	.	.	1	.	.	.	.	.	.	1	.	.	1
40	.	.	.	1	3	.	.	.	.	.	2	2	.	.	4
41	.	.	.	.	2	.	.	.	.	.	.	2	.	.	2
42	.	.	.	.	4	.	.	.	.	.	1	3	.	.	4
44	.	.	.	.	1	.	.	.	.	.	.	1	.	.	1
45	.	.	.	.	3	1	.	.	.	.	.	4	.	.	4
47	.	.	.	.	.	1	.	.	.	.	.	.	1	.	1
Total	.	1	4	10	14	2	.	.	3	7	7	13	1	.	31
Av. length	.	30	32	34	42	46	.	.	30	33	37	42	47	.	

Date August 24, 1938
St. No. 2412
Net N 100 H 5–0 m.
N 100 B 107–0 m.
Locality E. of Bouvet I.
Position {55° 41·9' S, 20° 29·4' E
Surface T. −1·80° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
27	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
28	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
30	.	1	2	.	.	.	.	.	2	1	.	.	.	.	3
31	.	.	1	1	.	.	.	.	1	1	.	.	.	.	2
32	.	2	1	.	.	.	.	.	3	.	.	.	.	.	3
33	.	.	2	1	.	.	.	.	.	3	.	.	.	.	3
34	.	.	1	1	.	.	.	.	.	2	.	.	.	.	2
35	.	.	.	1	1	.	.	.	.	.	2	.	.	.	2
37	.	.	.	.	1	.	.	.	.	.	1	.	.	.	1
38	.	.	.	.	1	.	.	.	.	.	.	1	.	.	1
39	.	.	.	.	.	1	.	.	.	.	.	1	.	.	1
Total	.	5	7	4	3	1	.	.	8	7	3	2	.	.	20
Av. length	.	30	32	33	37	39	.	.	30	33	36	39	.	.	

FEMALES

Date August 19, 1938
St. No. 2399
Net N 100 H 5–0 m.
N 100 B {98–0 m. / 300–150 m.
Locality S.E. of Bouvet I.
Position {54° 47'·1 S, 06° 31'·3 E.
Surface T. 1·71° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
27	.	1	.	.	.	.	.	1	.	.	.	.	.	.	1
28	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
29	.	3	.	.	.	.	.	1	1	1	.	.	.	.	3
30	.	1	2	.	.	.	.	.	1	2	.	.	.	.	3
32	.	.	1	.	.	.	.	.	.	1	.	.	.	.	1
33	.	1	.	1	.	.	.	.	.	1	1	.	.	.	2
34	.	.	3		.	.	.	.	.	3	.	.	.	.	3
35	.	1	1	1	.	.	.	.	.	2	.	1	.	.	3
36	.	.	1	1	.	.	.	.	.	.	2	.	.	.	2
37	.	.	2	.	.	.	.	.	.	.	2	.	.	.	2
38	.	.	1	1	.	.	.	.	.	.	1	1	.	.	2
40	.	.	.	1	.	.	.	.	.	.	.	1	.	.	1
42	.	.	.	2	.	.	.	.	.	.	.	2	.	.	2
Total	.	8	11	7	.	.	.	2	3	10	6	5	.	.	26
Av. length	.	30	35	38	.	.	.	28	29	33	36	39	.	.	

Date August 22, 1938
St. No. 2408
Net N 100 H 5–0 m.
N 100 B} 108–0 m.
N 70 B }
Locality E. of Bouvet I.
Position {54° 52'·45 S, 16° 22'·2 E
Surface T. −1·21° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
25	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
27	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
30	.	1	.	.	.	.	.	.	.	1	.	.	.	.	1
31	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
32	.	1	4	.	.	.	.	.	1	.	4	.	.	.	5
33	.	1	4	.	.	.	.	.	.	1	4	.	.	.	5
34	.	.	6	.	.	.	.	.	.	.	6	.	.	.	6
35	.	4	6	.	.	.	.	.	.	4	6	.	.	.	10
36	.	.	6	.	.	.	.	.	.	1	4	1	.	.	6
37	.	1	3	.	.	.	.	.	.	1	2	1	.	.	4
38	.	.	3	.	.	.	.	.	.	.	1	2	.	.	3
39	.	.	3	1	.	.	.	.	.	.	2	2	.	.	4
40	.	.	3	1	.	.	.	.	.	.	2	2	.	.	4
41	.	.	1	4	.	.	.	.	.	.	1	4	.	.	5
42	.	.	1	2	.	.	.	.	.	.	1	2	.	.	3
Total	1	10	40	8	.	.	.	1	3	8	33	14	.	.	59
Av. length	25	33	36	41	.	.	.	25	30	35	35	40	.	.	

Date August 23, 1938
St. No. 2411
Net N 100 B 35–0 m.
Locality E. of Bouvet I.
Position {56° 25' S, 19° 54'·7 E
Surface T. −1·70° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
26	.	1	.	.	.	.	.	1	.	.	.	.	.	.	1
27	.	1	.	.	.	.	.	1	.	.	.	.	.	.	1
36	.	.	2	.	.	.	.	.	.	1	1	.	.	.	2
Total	.	2	2	.	.	.	.	2	.	1	1	.	.	.	4
Av. length	.	27	36	.	.	.	.	27	.	36	36	.	.	.	

Date August 24, 1938
St. No. 2412
Net N 100 H 5–0 m.
N 100 B 107–0 m.
Locality E. of Bouvet I.
Position {55° 41·9' S, 20° 29·4' E
Surface T. −1·80° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
25	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
27	.	3	.	.	.	.	.	.	3	.	.	.	.	.	3
28	.	2	.	.	.	.	.	.	2	.	.	.	.	.	2
29	.	.	1	.	.	.	.	.	1	.	.	.	.	.	1
30	.	.	4	.	.	.	.	.	2	2	.	.	.	.	4
31	.	.	3	.	.	.	.	.	2	1	.	.	.	.	3
32	.	1	4	.	.	.	.	.	2	2	1	.	.	.	5
33	.	.	5	.	.	.	.	.	.	5	.	.	.	.	5
34	.	.	2	.	.	.	.	.	.	1	1	.	.	.	2
35	.	.	3	.	.	.	.	.	.	1	2	.	.	.	3
37	.	.	2	.	.	.	.	.	.	.	2	.	.	.	2
38	.	.	1	.	.	.	.	.	.	.	1	.	.	.	1
40	.	.	1	.	.	.	.	.	.	.	1	.	.	.	1
42	.	.	.	1	.	.	.	.	.	.	1	.	.	.	1
Total	.	7	26	1	.	.	.	.	13	12	9	.	.	.	34
Av. length	.	28	33	42	.	.	.	.	29	32	37	.	.	.	

MALES

Date	September 5, 1928	Locality	S. Georgia
St. No.	WS 277	Position	53° 52′·30 S, 38° 09′·30 W
Net	N 70 B 124–0 m.	Surface T.	−0·54° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
23	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
24	.	4	.	.	.	.	.	.	4	.	.	.	.	.	4
25	.	4	.	.	.	.	.	.	4	.	.	.	.	.	4
26	.	2	.	.	.	.	.	.	2	.	.	.	.	.	2
27	.	2	.	.	.	.	.	.	2	.	.	.	.	.	2
29	.	2	.	.	.	.	.	.	2	.	.	.	.	.	2
30	.	.	1	.	.	.	.	.	.	1	.	.	.	.	1
31	.	.	1	.	.	.	.	.	1	.	.	.	.	.	1
32	.	.	1	.	.	.	.	.	.	1	.	.	.	.	1
33	.	.	.	1	.	.	.	.	.	1	.	.	.	.	1
34	.	.	.	1	.	.	.	.	.	.	.	1	.	.	1
35	.	.	.	1	1	.	.	.	.	.	2	.	.	.	2
38	.	.	.	.	1	.	.	.	.	.	.	.	1	.	1
40	.	.	.	1	3	.	.	.	.	.	.	3	1	.	4
41	.	.	.	.	1	1	.	.	.	.	.	.	2	.	2
42	.	.	.	.	1	.	.	.	.	.	.	.	1	.	1
45	.	.	.	.	1	3	.	.	.	.	.	.	4	.	4
46	.	.	.	.	2	2	.	.	.	.	.	.	4	.	4
47	.	.	.	.	.	4	.	.	.	.	.	.	4	.	4
48	.	.	.	.	.	3	.	.	.	.	.	.	3	.	3
49	.	.	.	.	.	5	.	.	.	.	.	.	5	.	5
50	.	.	.	.	.	1	.	.	.	.	.	.	1	.	1
55	.	.	.	.	.	1	.	.	.	.	.	.	1	.	1
Total	.	15	3	4	10	20	.	.	16	3	2	4	27	.	52
Av. length	.	26	31	36	41	48	.	.	26	32	35	39	46	.	

Date	September 17, 1928	Locality	S. Georgia
St. No.	WS 282	Position	54° 22′·30 S, 34° 43′·00 W
Net	N 70 B 137–0 m.	Surface T.	−1·35° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
13	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
14	2	.	.	.	.	.	.	2	.	.	.	.	.	.	2
15	4	.	.	.	.	.	.	4	.	.	.	.	.	.	4
28	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
29	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
34	.	.	.	.	1	.	.	.	.	.	1	.	.	.	1
38	.	.	.	.	1	.	.	.	.	.	.	1	.	.	1
39	.	.	.	.	1	.	.	.	.	.	.	.	1	.	1
40	.	.	.	.	1	.	.	.	.	.	.	1	.	.	1
45	.	.	.	.	3	3	.	.	.	.	.	.	6	.	6
47	.	.	.	.	.	1	.	.	.	.	.	.	1	.	1
48	.	.	.	.	.	4	.	.	.	.	.	.	4	.	4
49	.	.	.	.	.	2	.	.	.	.	.	.	2	.	2
50	.	.	.	.	.	3	.	.	.	.	.	.	3	.	3
51	.	.	.	.	.	1	.	.	.	.	.	.	1	.	1
52	.	.	.	.	.	1	2	.	.	.	.	.	1	2	3
53	.	.	.	.	.	2	.	.	.	.	.	.	1	1	2
55	.	.	.	.	.	1	2	.	.	.	.	.	1	2	3
57	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
Total	7	2	.	.	7	18	5	7	2	.	1	2	21	6	39
Av. length	14	29	.	.	41	49	54	14	29	.	34	39	48	54	

Date	September 24, 1938	Locality	S. of Bouvet I.
St. No.	2430	Position	54° 14′·1 S, 00° 29′·0 E
Net	N 100 H 5–0 m.	Surface T.	−0·99° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
40	.	.	.	.	.	1	.	.	.	.	.	.	1	.	1
Total	.	.	.	.	.	1	.	.	.	.	.	.	1	.	1
Av. length	.	.	.	.	.	40	.	.	.	.	.	.	40	.	

FEMALES

Date	September 5, 1928	Locality	S. Georgia
St. No.	WS 277	Position	53° 52′·30 S, 38° 09′·30 W
Net	N 70 B 124–0 m.	Surface T.	−0·54° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
21	3	.	.	.	.	.	.	1	2	.	.	.	.	.	3
22	4	.	.	.	.	.	.	.	4	.	.	.	.	.	4
23	1	1	.	.	.	.	.	.	1	1	.	.	.	.	2
24	2	3	.	.	.	.	.	.	5	.	.	.	.	.	5
25	3	3	.	.	.	.	.	.	5	1	.	.	.	.	6
26	.	3	.	.	.	.	.	.	2	1	.	.	.	.	3
27	.	4	.	.	.	.	.	.	.	4	.	.	.	.	4
28	.	1	.	.	.	.	.	.	.	1	.	.	.	.	1
31	.	.	.	1	.	.	.	.	.	.	1	.	.	.	1
32	.	.	1	.	.	.	.	.	.	1	.	.	.	.	1
33	.	.	.	2	.	.	.	.	.	.	1	1	.	.	2
35	.	.	.	1	.	.	.	.	.	.	.	1	.	.	1
36	.	.	.	1	.	.	.	.	.	.	1	.	.	.	1
40	.	.	.	1	.	.	.	.	.	.	.	1	.	.	1
41	.	.	.	1	.	.	.	.	.	.	.	1	.	.	1
43	.	.	.	1	.	.	.	.	.	.	.	1	.	.	1
44	.	.	.	1	.	.	.	.	.	.	.	1	.	.	1
45	.	.	.	2	.	.	.	.	.	.	.	2	.	.	2
46	.	.	.	1	.	.	.	.	.	.	.	1	.	.	1
48	.	.	.	1	.	.	.	.	.	.	.	1	.	.	1
49	.	.	.	1	1	.	.	.	.	.	.	2	.	.	2
Total	13	15	1	14	1	.	.	1	19	9	3	12	.	.	44
Av. length	23	26	32	41	49	.	.	21	24	27	33	43	.	.	

Date	September 17, 1928	Locality	S. Georgia
St. No.	WS 282	Position	54° 22′·30 S, 34° 43′·00 W
Net	N 70 B 137–0 m.	Surface T.	−1·35° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
12	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
14	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
15	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
16	2	.	.	.	.	.	.	2	.	.	.	.	.	.	2
31	.	.	1	.	.	.	.	.	.	1	.	.	.	.	1
33	.	.	.	1	.	.	.	.	.	.	1	.	.	.	1
35	.	.	.	2	.	.	.	.	.	.	2	.	.	.	2
36	.	.	.	1	.	.	.	.	.	.	.	1	.	.	1
37	.	.	.	1	.	.	.	.	.	.	1	.	.	.	1
38	.	.	.	3	.	.	.	.	.	.	1	2	.	.	3
39	.	.	.	1	.	.	.	.	.	.	.	1	.	.	1
42	.	.	.	1	.	.	.	.	.	.	.	1	.	.	1
45	.	.	.	1	.	.	.	.	.	.	.	1	.	.	1
46	.	.	.	1	.	.	.	.	.	.	.	1	.	.	1
51	.	.	.	1	.	.	.	.	.	.	.	1	.	.	1
52	.	.	.	3	.	.	.	.	.	.	.	3	.	.	3
55	.	.	.	1	.	.	.	.	.	.	.	1	.	.	1
Total	5	.	1	17	.	.	.	5	.	1	5	12	.	.	23
Av. length	15	.	31	48	.	.	.	15	.	31	36	46	.	.	

Date	September 24, 1938	Locality	S. of Bouvet I.
St. No.	2430	Position	54° 14′·1 S, 00° 29′·0 E
Net	N 100 H 5–0 m. N 100 B 117–0 m.	Surface T.	−0·99° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
25	.	1	.	.	.	.	.	1	.	.	.	.	.	.	1
26	.	1	.	.	.	.	.	1	.	.	.	.	.	.	1
32	.	.	1	.	.	.	.	.	.	.	1	.	.	.	1
38	.	.	1	.	.	.	.	.	.	.	1	.	.	.	1
42	.	.	.	1	.	.	.	.	.	.	.	1	.	.	1
46	.	.	.	1	.	.	.	.	.	.	.	1	.	.	1
Total	.	2	2	2	.	.	.	2	.	.	2	2	.	.	6
Av. length	.	26	35	44	.	.	.	26	.	.	35	44	.	.	

MALES

Date October 2, 1928
St. No. WS 290
Net N 70 H 0–5 m.
Locality S. Georgia
Position 54° 23′ 10 S, 35° 44′·00 W
Surface T. −1·08° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
13	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
15	5	.	.	.	.	.	.	5	.	.	.	.	.	.	5
16	2	.	.	.	.	.	.	2	.	.	.	.	.	.	2
17	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
22	.	1	.	.	.	.	.	1	.	.	.	.	.	.	1
28	.	1	.	.	.	.	.	1	.	.	.	.	.	.	1
29	.	2	.	.	.	.	.	.	2	.	.	.	.	.	2
30	.	1	1	.	.	.	.	.	1	1	.	.	.	.	2
31	.	3	1	.	.	.	.	.	3	1	.	.	.	.	4
32	.	.	3	1	.	.	.	.	.	4	.	.	.	.	4
33	.	2	5	1	.	.	.	.	1	7	.	.	.	.	8
35	.	.	.	2	1	.	.	.	.	.	2	1	.	.	3
38	.	.	.	.	1	.	.	.	.	.	.	1	.	.	1
41	.	.	.	.	1	.	.	.	.	.	.	1	.	.	1
Total	9	10	10	4	3	.	.	11	7	13	2	3	.	.	36
Av. length	15	30	30	34	38	.	.	17	26	32	35	38	.	.	

Date October 4, 1928
St. No. WS 295
Net N 100 B 97–0 m.
Locality S. Georgia
Position 55° 23′·40 S, 34° 41′·00 W
Surface T. −1·10° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
13	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
14	4	.	.	.	.	.	.	4	.	.	.	.	.	.	4
15	5	.	.	.	.	.	.	5	.	.	.	.	.	.	5
16	4	.	.	.	.	.	.	4	.	.	.	.	.	.	4
17	3	.	.	.	.	.	.	3	.	.	.	.	.	.	3
25	.	2	.	.	.	.	.	.	2	.	.	.	.	.	2
26	.	4	.	.	.	.	.	.	4	.	.	.	.	.	4
27	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
28	.	3	.	.	.	.	.	.	3	.	.	.	.	.	3
29	.	1	.	.	.	.	.	1	.	.	.	.	.	.	1
30	.	6	.	1	.	.	.	1	4	2	.	.	.	.	7
32	.	1	1	.	.	.	.	.	1	1	.	.	.	.	2
33	.	.	1	1	.	.	.	.	.	1	1	.	.	.	2
34	.	.	.	2	.	.	.	.	.	.	2	.	.	.	2
35	.	.	.	3	.	.	.	.	.	2	1	.	.	.	3
36	.	.	.	1	.	.	.	.	.	.	1	.	.	.	1
37	.	.	.	.	1	.	.	.	.	.	.	1	.	.	1
Total	17	18	2	8	1	.	.	19	15	6	5	1	.	.	46
Av. length	15	28	33	34	37	.	.	17	28	33	34	37	.	.	

Date October 5, 1928
St. No. WS 298
Net N 100 B 94–0 m.
Locality S. Georgia
Position 55° 27′ 30 S, 32° 21′·40 W
Surface T. −1·76° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
27	.	2	2	.	.	.	.	.	3	1	.	.	.	.	4
28	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
30	.	2	6	.	.	.	.	.	2	6	.	.	.	.	8
31	.	.	1	.	.	.	.	.	1	.	.	.	.	.	1
32	.	.	1	.	.	.	.	.	.	1	.	.	.	.	1
33	.	.	1	1	.	.	.	.	.	1	1	.	.	.	2
37	.	.	.	.	1	.	.	.	.	.	.	1	.	.	1
38	.	.	.	.	1	1	.	.	.	.	.	1	1	.	2
39	.	.	.	.	1	.	.	.	.	.	.	1	.	.	1
41	.	.	.	.	.	1	.	.	.	.	.	.	1	.	1
43	.	.	.	.	.	2	.	.	.	.	.	.	2	.	2
44	.	.	.	.	.	1	.	.	.	.	.	.	1	.	1
46	.	.	.	.	.	1	.	.	.	.	.	.	1	.	1
48	.	.	.	.	.	2	.	.	.	.	.	.	2	.	2
49	.	.	.	.	.	4	.	.	.	.	.	.	4	.	4
50	.	.	.	.	.	3	.	.	.	.	.	.	3	.	3
51	.	.	.	.	.	.	2	.	.	.	.	.	.	2	2
52	.	.	.	.	.	1	.	.	.	.	.	.	1	.	1
54	.	.	.	.	.	1	.	.	.	.	.	.	1	.	1
55	.	.	.	.	.	2	1	.	.	.	.	.	2	1	3
Total	.	5	11	1	3	19	3	.	7	9	1	3	19	3	42
Av. length	.	28	30	33	38	47	52	.	29	30	33	38	47	52	

FEMALES

Date October 2, 1928
St. No. WS 290
Net N 70 H 0–5 m.
Locality S. Georgia
Position 54° 23′ 10 S, 35° 44′·00 W
Surface T. −1·08° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
13	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
14	2	.	.	.	.	.	.	2	.	.	.	.	.	.	2
15	4	.	.	.	.	.	.	4	.	.	.	.	.	.	4
16	3	.	.	.	.	.	.	3	.	.	.	.	.	.	3
22	.	.	1	.	.	.	.	.	.	1	.	.	.	.	1
25	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
26	.	1	2	.	.	.	.	.	2	1	.	.	.	.	3
27	.	1	2	.	.	.	.	.	1	2	.	.	.	.	3
28	.	.	5	.	.	.	.	.	.	5	.	.	.	.	5
29	.	1	4	.	.	.	.	.	.	5	.	.	.	.	5
30	.	2	5	.	.	.	.	.	.	5	2	.	.	.	7
31	.	.	2	.	.	.	.	.	.	1	1	.	.	.	2
32	.	.	1	.	.	.	.	.	.	1	.	.	.	.	1
33	.	.	2	.	.	.	.	.	.	1	1	.	.	.	2
34	.	.	3	.	.	.	.	.	.	.	3	.	.	.	3
35	.	.	1	.	.	.	.	.	.	.	1	.	.	.	1
37	.	.	.	1	.	.	.	.	.	.	.	1	.	.	1
Total	10	6	28	1	.	.	.	10	4	22	8	1	.	.	45
Av. length	15	28	30	37	.	.	.	15	26	29	33	37	.	.	

Date October 4, 1928
St. No. WS 295
Net N 100 B 97–0 m.
Locality S. Georgia
Position 55° 23′ 40 S, 34° 41′·00 W
Surface T. −1·10° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
13	3	.	.	.	.	.	.	3	.	.	.	.	.	.	3
14	7	.	.	.	.	.	.	7	.	.	.	.	.	.	7
15	15	.	.	.	.	.	.	15	.	.	.	.	.	.	15
16	7	.	.	.	.	.	.	7	.	.	.	.	.	.	7
17	2	.	.	.	.	.	.	2	.	.	.	.	.	.	2
26	.	1	1	.	.	.	.	.	1	1	.	.	.	.	2
27	.	3	1	.	.	.	.	.	.	3	1	.	.	.	4
28	.	.	2	.	.	.	.	.	.	1	1	.	.	.	2
29	.	.	2	.	.	.	.	.	.	.	2	.	.	.	2
33	.	.	1	.	.	.	.	.	.	.	1	.	.	.	1
37	.	.	.	1	.	.	.	.	.	.	.	1	.	.	1
Total	34	4	7	1	.	.	.	34	1	5	5	1	.	.	46
Av. length	15	27	29	37	.	.	.	15	26	27	29	37	.	.	

Date October 5, 1928
St. No. WS 298
Net N 100 B 94–0 m.
Locality S. Georgia
Position 55° 27′ 30 S, 32° 21′·40 W
Surface T. −1·76° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
25	.	1	.	.	.	.	.	.	.	1	.	.	.	.	1
27	.	1	2	.	.	.	.	.	.	2	1	.	.	.	3
28	.	.	1	.	.	.	.	.	.	.	1	.	.	.	1
29	.	.	2	.	.	.	.	.	.	1	1	.	.	.	2
30	.	.	1	.	.	.	.	.	.	.	1	.	.	.	1
31	.	.	1	.	.	.	.	.	.	.	1	.	.	.	1
32	.	.	2	.	.	.	.	.	.	1	1	.	.	.	2
33	.	.	1	1	.	.	.	.	.	.	1	1	.	.	2
34	.	.	1	1	.	.	.	.	.	.	1	1	.	.	2
35	.	.	1	1	.	.	.	.	.	.	1	1	.	.	2
36	.	.	1	1	.	.	.	.	.	.	1	1	.	.	2
37	.	.	1	.	.	.	.	.	.	.	.	1	.	.	1
38	.	.	.	.	1	.	.	.	.	.	.	1	.	.	1
39	.	.	.	2	.	.	.	.	.	.	.	2	.	.	2
40	.	.	.	1	.	.	.	.	.	.	.	1	.	.	1
41	.	.	.	1	.	.	.	.	.	.	.	1	.	.	1
42	.	.	.	.	1	.	.	.	.	.	.	1	.	.	1
43	.	.	.	.	1	.	.	.	.	.	.	1	.	.	1
45	.	.	.	.	1	.	.	.	.	.	.	1	.	.	1
46	.	.	.	1	1	.	.	.	.	.	.	2	.	.	2
50	.	.	.	.	2	.	.	.	.	.	.	1	.	1	2
51	.	.	.	.	1	.	.	.	.	.	.	1	.	.	1
52	.	.	.	.	1	.	.	.	.	.	.	1	.	.	1
56	.	.	.	.	1	.	.	.	.	.	.	.	.	1	1
Total	.	2	14	9	10	.	.	.	.	5	10	18	.	2	35
Av. length	.	26	31	38	47	.	.	.	.	28	32	42	.	53	

MALES

Date October 6, 1928
St. No WS 304
Net N 100 B 110–0 m
Locality S. Georgia
Position {54° 54′·40 S, 30° 21′·20 W
Surface T. −1·58° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
25	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
26	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
31	.	.	.	1	.	.	.	.	.	1	.	.	.	.	1
35	.	.	.	.	2	.	.	.	.	.	.	2	.	.	2
43	.	.	.	.	.	1	.	.	.	.	.	.	1	.	1
45	.	.	.	.	.	1	.	.	.	.	.	.	1	.	1
47	.	.	.	.	.	1	.	.	.	.	.	.	1	.	1
48	.	.	.	.	.	1	.	.	.	.	.	.	1	.	1
Total	.	2	.	1	2	4		.	2	1	.	2	4	.	9
Av. length	.	26	.	31	35	46	.	.	26	31	.	35	46	.	

Date October 16–17, 1930
St. No. 453
Net N 100 B 164–0 m.
Locality Bouvet I. to S. Georgia
Position {54° 05½′ S, 03° 57½′ E
Surface T. −1·60° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
35	.	.	.	.	1	.	.	.	.	.	.	1	.		1
Total	.	.	.	.	1	.	.	.	.	.	.	1		.	1
Av. length	.	.		.	35	.	.	.	.	.	.	35	.		

Date October 17, 1930
St. No. 454
Net N 70 B 192–0 m.
Locality Bouvet I. to S. Georgia
Position {53° 42′·00 S, 04° 42′·00 E
Surface T. −1·38° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
12	9						.	9	.		.		.	.	9
13	2		.			.	.	2	.	.	.	.	.	.	2
14	7	.			.		.	7	.	.	.	.	.	.	7
15	16	.	.		.	.	.	16	.	.	.	.	.	.	16
16	21	.	.		.	.	.	21	.	.	.	.	.	.	21
17	23	.	.		.			23	.	.	.	.	.	.	23
18	12	.	.		.	.	.	12	.	.	.	.	.	.	12
19	2	.	.	.	.	.		2	.	.	.	.	.	.	2
20	3	.	.		.	.	.	3	.	.	.	.	.	.	3
39	.	.	.		.	1	.	.	.	.	.	.	1	.	1
40	.	.			.	4	.	.	.	.	.	.	4	.	4
41	.	.			.	1	.	.	.	.	.	.	1	.	1
43	.		.		.	3	.	.		.	.	.	3	.	3
44	.		.		.	2		.		.	.	.	2	.	2
45		.	.		.	4		.		.	.	.	4	.	4
46	.		.		.	1	.		.	.	.	.	1	.	1
49	.		.	.	.	1	.	.	.	.	.	.	1	.	1
51	.	.	.		.	1	1	.	.	.	.	.	1	1	2
55	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
Total	95	.	.	.	.	18	2	95	.	.	.	.	18	2	115
Av. length	16	.	.	.	.	41	53	16	.	.	.	.	41	53	

Date October 18, 1930
St. No. 455
Net N 100 B 116–0 m.
Locality Bouvet I. to S. Georgia
Position {53° 55½′ S, 04° 47′ E
Surface T. −1·59 C

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
12	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
13	2	.	.	.	.	.	.	2	.	.	.	.	.	.	2
14	6	.	.	.	.	.	.	6	.	.	.	.	.	.	6
15	6	.	.	.	.	.	.	6	.	.	.	.	.	.	6
16	4	.	.	.	.	.	.	4	.	.	.	.	.	.	4
17	3	.	.	.	.	.	.	3	.	.	.	.	.	.	3
32	.	.	.	1	.	.	.	.	.	.	.	1	.	.	1
39	.	.	.	.	.	1	.	.	.	.	.	.	1	.	1
41	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
42	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
45	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
Total	22	.	.	1	.	1	3	22	.	.	.	1	1	3	27
Av. length	15	.	.	32	.	39	43	15	.	.	.	32	39	43	

FEMALES

Date October 6, 1928
St. No. WS 304
Net N 100 B 110–0 m.
Locality S. Georgia
Position {54° 54′·40 S, 30° 21′·20 W
Surface T. −1·58° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
26	.	1	.	.	.	.	.	.	.	1	.	.	.	.	1
29	.	.	1	.	.	.	.	.	.	1	.	.	.	.	1
30	.		1	1	.	.	.	.	.	1	1	.	.	.	2
31	.	.	1	.	.	.	.	.	.	.	1	.	.	.	1
34	.	.	.	1	.	.	.	.	.	.	1	.	.	.	1
40	.	.	.	1	.	.	.	.	.	.	.	1	.	.	1
44	.	.	.	1	.	.	.	.	.	.	.	1	.	.	1
Total	.	1	3	4	.	.	.	.	.	3	3	2	.	.	8
Av. length	.	26	30	37	.	.	.	.	.	28	32	42	.	.	

Date October 16–17, 1930
St. No. 453
Net N 100 B 164–0 m.
Locality Bouvet I. to S. Georgia
Position {54° 05½′ S, 03° 57½′ E
Surface T. −1·60° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
34	.	.	.	1	.	.	.	.	.	.	.	1		.	1
35	.	.	.	1	.	.	.	.	.	.	.	1	.	.	1
Total	.	.	.	2	.	.	.	.	.	.	.	2	.	.	2
Av. length	.	.	.	35	.	.	.	.	.	.	.	35	.	.	

Date October 17, 1930
St. No. 454
Net N 70 B 192–0 m.
Locality Bouvet I. to S. Georgia
Position {53° 42′·00 S, 04° 42′·00 E
Surface T. −1·38° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
11	2	.	.	.	.		.	2	.	.	.	.	.	.	2
12	7	.	.	.	.	.	.	7	.	.	.	.	.	.	7
13	4	.	.	.	.	.	.	4	.	.	.	.	.	.	4
14	6	.	.	.	.	.	.	6	.	.	.	.	.	.	6
15	22	.	.	.	.	.	.	22	.	.	.	.	.	.	22
16	22	.	.	.	.	.	.	22	.	.	.	.	.	.	22
17	15	.	.	.	.	.	.	15	.	.	.	.	.	.	15
18	4	.	.	.	.	.	.	4	.	.	.	.	.	.	4
19	7	.	.	.	.	.	.	7	.	.	.	.	.	.	7
20	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
35	.	.	.	2	.	.	.	.	.	.	.	2	.	.	2
36	.	.	.	4	.	.	.	.	.	.	2	2	.	.	4
37	.	.	1	.	.	.	.	.	.	.	1	.	.	.	1
38	.	.	.	1	.	.	.	.	.	.	.	1	.	.	1
39	.	.	.	3	.	.	.	.	.	.	.	3	.	.	3
40	.	.	1	2	.	.	.	.	.	.	.	3	.	.	3
42	.	.	.	3	.	.	.	.	.	.	.	3	.	.	3
43	.	.	.	4	.	.	.	.	.	.	.	4	.	.	4
44	.	.	.	1	.	.	.	.	.	.	.	1	.	.	1
45	.	.	.	2	.	.	.	.	.	.	.	2	.	.	2
46	.	.	.	1	.	.	.	.	.	.	.	1	.	.	1
48	.	.	.	1	.	.	.	.	.	.	.	1	.	.	1
49	.	.	.	1	.	.	.	.	.	.	.	1	.	.	1
50	.	.	.	1	.	.	.	.	.	.	.	1	.	.	1
51	.	.	.	.	1	.	.	.	.	.	.	1	.	.	1
Total	90	.	2	26	1	.	.	90	.	.	3	26	.	.	119
Av. length	16	.	39	41	51	.	.	16	.	.	36	42	.	.	

Date October 18, 1930
St. No. 455
Net N 100 B 116–0 m.
Locality Bouvet I. to S. Georgia
Position {53° 55½′ S, 04° 47′ E
Surface T. −1·59 C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
11	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
12	3	.	.	.	.	.	.	3	.	.	.	.	.	.	3
13	2	.	.	.	.	.	.	2	.	.	.	.	.	.	2
14	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
15	13	.	.	.	.	.	.	13	.	.	.	.	.	.	13
16	4	.	.	.	.	.	.	4	.	.	.	.	.	.	4
17	3	.	.	.	.	.	.	3	.	.	.	.	.	.	3
19	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
35	.	.	.	1	.	.	.	.	.	.	.	1	.	.	1
38	.	.	.	2	.	.	.	.	.	.	.	2	.	.	2
44	.	.	.	1	.	.	.	.	.	.	.	1	.	.	1
45	.	.	.	1	.	.	.	.	.	.	.	1	.	.	1
Total	28	.	.	5	.	.	.	28	.	.	.	5	.	.	33
Av. length	15	.	.	40	.	.	.	15	.	.	.	40	.	.	

MALES

Date October 19, 1930
St. No. 459
Net N 100 B 183–0 m.
Locality Bouvet I. to S. Georgia
Position 55° 00¼′ S., 02° 00′ E.
Surface T. 1·38° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
13	3							3							3
14	1							1							1
15	3							3							3
16	5							5							5
17	1							1							1
18	2							2							2
19	2							2							2
37				1						1					1
43							2							2	2
Total	17			1			2	17		1				2	20
Av. length	16			37			43	16		37				43	

FEMALES

Date October 19, 1930
St. No. 459
Net N 100 B } 183–0 m.
N 70 B }
Locality Bouvet I. to S. Georgia
Position 55° 00¼′ S., 02° 00′ E.
Surface T. 1·38° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
12	2							2							2
14	4							4							4
15	11							11							11
16	5							5							5
17	2							2							2
18	1							1							1
19	1							1							1
37				4							2	2			4
38				3							2	1			3
39				2								2			2
40				1							1				1
Total	26			10				26			5	5			36
Av. length	15			38				15			38	38			

Date October 20, 1930
St. No. 460
Net N 100 B 155–0 m.
Locality Bouvet I. to S. Georgia
Position 56° 46′ S., 00° 41¾′ W
Surface T. −1·29° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
11	1							1							1
12	2							2							2
13	1							1							1
14	7							7							7
15	3							3							3
16	3							3							3
17	1							1							1
38							1							1	1
Total	18						1	18						1	19
Av. length	14						38	14						38	

Date October 20, 1930
St. No. 460
Net N 100 B 155–0 m.
Locality Bouvet I. to S. Georgia
Position 56° 46′ S., 00° 41¾′ W
Surface T. −1·29° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
12	2							2							2
13	5							5							5
14	5							5							5
15	7							7							7
16	2							2							2
17	4							4							4
18	1							1							1
Total	26							26							26
Av. length	15							15							

Date October 22, 1930
St. No. 461 D
Net N 100 B 490–385 m.
Locality Bouvet I. to S. Georgia
Position 56° 41′·00 S., 02° 24′·00 W
Surface T. −1·72° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
33					1								1		1
Total					1								1		1
Av. length					33								33		

Date October 22, 1930
St. No. 461 D
Net N 100 B 490–385 m.
Locality Bouvet I. to S. Georgia
Position 56° 41′·00 S., 02° 24′·00 W
Surface T. −1·72° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
36				1								1			1
37				1								1			1
40				1								1			1
49				1									1		1
Total				4								3	1		4
Av. length				41								38	49		

Date October 22, 1930
St. No. 461 G
Net N 100 B 700–560 (315) m.
Locality Bouvet I. to S. Georgia
Position 56° 44¾′ S., 02° 21½′ W
Surface T. −1·74° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
35					2		1						2	1	3
37						6	1							7	7
38						5	2							7	7
39						5	3						2	6	8
40					1	3	3							7	7
41						1	7							8	8
42						4	7							11	11
43						1	10							11	11
44						4	1						1	4	5
45						2	8							10	10
46						1	4						1	4	5
47						2	1							3	3
48						3	1							4	4
49						1	2							3	3
51							1							1	1
Total					3	38	52						6	87	93
Av. length					37	42	43						40	42	

Date October 22, 1930
St. No. 461 G
Net N 100 B 700–560 (315) m.
Locality Bouvet I. to S. Georgia
Position 56° 44¾′ S., 02° 21½′ W
Surface T. −1·74° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
32				2								2			2
33				2								2			2
34				3								3			3
35				4								4			4
36				4								4			4
37				8								8			8
38		1		7	1					1		8			9
39				12								12			12
40				13								13			13
41				8	3							10	1		11
42				12	2							14			14
43				7	1							8			8
44		1		13	1						1	14			15
45				5	1							6			6
46				5	2							6	1		7
47					2							2			2
48				1	1							2			2
50				1									1		1
Total		3		107	14					1	1	118	3		123
Av. length		41		40	44					38	44	41	46		

MALES

Date	October 23, 1930	Locality	Bouvet I. to S. Georgia
St. No.	462	Position	56° 01'·00 S, 07° 28' 00 W
Net	N 100 B 90–0 m.	Surface T.	−1·55° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
12	2	.	.	.	.	.	.	2	.	.	.	.	.	.	2
13	2	.	.	.	.	.	.	2	.	.	.	.	.	.	2
14	5	.	.	.	.	.	.	5	.	.	.	.	.	.	5
15	11	.	.	.	.	.	.	11	.	.	.	.	.	.	11
16	2	.	.	.	.	.	.	2	.	.	.	.	.	.	2
17	2	.	.	.	.	.	.	2	.	.	.	.	.	.	2
18	2	.	.	.	.	.	.	2	.	.	.	.	.	.	2
51	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
Total	26	.	.	.	.	.	1	26	.	.	.	.	.	1	27
Av. length	15	.	.	.	.	.	51	15	.	.	.	.	.	51	

Date	October 25, 1930	Locality	Bouvet I. to S. Georgia
St. No.	463	Position	55° 42'·00 S, 10° 54' 00 W
Net	N 100 B 132–0 m.	Surface T.	−1·80° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
11	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
12	2	.	.	.	.	.	.	2	.	.	.	.	.	.	2
13	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
14	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
15	9	.	.	.	.	.	.	9	.	.	.	.	.	.	9
16	6	.	.	.	.	.	.	6	.	.	.	.	.	.	6
17	8	.	.	.	.	.	.	8	.	.	.	.	.	.	8
19	2	.	.	.	.	.	.	2	.	.	.	.	.	.	2
33	.	.	.	1	.	.	.	.	.	.	.	1	.	.	1
Total	30	.	.	1	.	.	.	30	.	.	.	1	.	.	31
Av. length	16	.	.	33	.	.	.	16	.	.	.	33	.	.	

Date	October 26, 1930	Locality	Bouvet I. to S. Georgia
St. No.	465	Position	55° 49'·00 S, 14° 02½' W
Net	N 100 B 113–0 m.	Surface T.	−1·68° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
47	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
50	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
Total	.	.	.	.	.	.	2	.	.	.	.	.	.	2	2
Av. length	.	.	.	.	.	.	49	.	.	.	.	.	.	49	

Date	October 31, 1930	Locality	Bouvet I. to S. Georgia
St. No.	471	Position	54° 57'·00 S, 27° 59½' W
Net	N 100 B 168–0 m.	Surface T.	−1·62° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
38	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
Total	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
Av. length	.	.	.	.	.	.	38	.	.	.	.	.	.	38	

FEMALES

Date	October 23, 1930	Locality	Bouvet I. to S. Georgia
St. No.	462	Position	56° 01'·00 S, 07° 28'·00 W
Net	N 100 B 90–0 m	Surface T.	−1·55° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
12	2	.	.	.	.	.	.	2	.	.	.	.	.	.	2
14	1	.	.		.	.	.	1	.	.	.	.	.	.	1
15	6	.	.		.	.	.	6	.		.	.	.	.	6
16	5	.	.	.	.	.	.	5	.	.	.	.	.	.	5
17	1	.	.	.	.	.	.	1	.		.	.	.	.	1
18	2	.	.	.	.	.	.	2	.		.	.	.	.	2
19	1	.	.	.	.	.	.	1			.	.	.	.	1
40	.	.	.	1	.	.	.	.	.	.	.	1	.	.	1
Total	18	.	.	1	.	.	.	18	.	.	.	1	.	.	19
Av. length	16	.	.	40	.	.	.	16	.	.	.	40	.	.	

Date	October 25, 1930	Locality	Bouvet I. to S. Georgia
St. No.	463	Position	55° 42'·00 S, 10° 54'·00 W
Net	N 100 B 132–0 m.	Surface T.	−1·80° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
11	1	.		.	.	.	.	1	.	.		.	.	.	1
13	2	.	.	.	.	.	.	2	.	.	.	.	.	.	2
14	2	.	.	.	.	.	.	2	.	.	.	.	.	.	2
15	10	.	.	.	.	.	.	10	.	.	.	.	.	.	10
16	4	.	.	.	.	.	.	4	.	.	.	.	.	.	4
17	2	.	.	.	.	.	.	2	.	.	.	.	.	.	2
19	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
44	.	.	.	1	.	.	.	.	.	.	.	1	.	.	1
Total	22	.	.	1	.	.	.	22	.	.	.	1	.	.	23
Av. length	15	.	.	44	.	.	.	15	.	.	.	44	.	.	

Date	October 26, 1930	Locality	Bouvet I. to S. Georgia
St. No.	465	Position	55° 49'·00 S, 14° 02½' W
Net	N 100 B 113–0 m.	Surface T.	−1·68° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
39	.	.	.	2	.	.	.	.	.	.	.	2	.	.	2
40	.	.	.	1	.	.	.	.	.	.	.	1	.	.	1
Total	.	.	.	3	.	.	.	.	.	.	.	3	.	.	3
Av. length	.	.	.	39	.	.	.	.	.	.	.	39	.	.	

Date	October 26, 1930	Locality	Bouvet I. to S. Georgia
St. No.	464	Position	56° 03'·00 S, 12° 18'·00 W
Net	N 100 H 67 (–0) m.	Surface T.	−1·75° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
48	.	.	.	1	.	.	.	.	.	.	.	1	.	.	1
Total	.	.	.	1	.	.	.	.	.	.	.	1	.	.	1
Av. length	.	.	.	48	.	.	.	.	.	.	.	48	.	.	

MALES

Date November 19, 1929
St. No. W.S. Alongside Deception I.
Net N 100 B 0–5 m.
Locality S. Shetland Is.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
42	.	.	.	.	.	.	2	.	.	.	.	.	.	2	2
44	.	.	.	.	.	.	2	.	.	.	.	.	.	2	2
47	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
Total	.	.	.	.	.	.	5	.	.	.	.	.	.	5	5
Av. length	.	.	.	.	.	.	44	.	.	.	.	.	.	44	

Date November 13, 1930
St. No. 480
Net N 100 B 161–0 m.
Locality S. Georgia
Position 53° 40½′ S., 39° 54′ W
Surface T. −0·58° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
14	2	.	.	.	.	.	.	2	.	.	.	.	.	.	2
Total	2		.	.	.	.	.	2	.	.	.	.	.	.	2
Av. length	14	.	.	.	.	.	.	14	.	.	.	.	.	.	

Date November 16, 1930
St. No. 484
Net N 100 B 73–0 m.
Locality S. Georgia
Position 53° 52¼′ S., 37° 05½′ W
Surface T. −0·56° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
10	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
11	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
12	4	.	.	.	.	.	.	4	.	.	.	.	.	.	4
13	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
15	6	.	.	.	.	.	.	6	.	.	.	.	.	.	6
16	7	.	.	.	.	.	.	7	.	.	.	.	.	.	7
17	6	.	.	.	.	.	.	6	.	.	.	.	.	.	6
18	8	.	.	.	.	.	.	8	.	.	.	.	.	.	8
19	6	.	.	.	.	.	.	6	.	.	.	.	.	.	6
20	2	.	.	.	.	.	.	2	.	.	.	.	.	.	2
21	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
Total	43	.	.	.	.	.	.	43	.	.	.	.	.	.	43
Av. length	16	.	.	.	.	.	.	16	.	.	.	.	.	.	

Date November 18, 1930
St. No. 492
Net N 100 B 148–0 m.
Locality S. Georgia
Position 53° 12¼′ S., 37° 04¼′ W
Surface T. −0·35° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
14	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
15	2	.	.	.	.	.	.	2	.	.	.	.	.	.	2
16	2	.	.	.	.	.	.	2	.	.	.	.	.	.	2
18	3	.	.	.	.	.	.	3	.	.	.	.	.	.	3
19	5	.	.	.	.	.	.	5	.	.	.	.	.	.	5
20	2	.	.	.	.	.	.	2	.	.	.	.	.	.	2
21	2	.	.	.	.	.	.	2	.	.	.	.	.	.	2
22	4	.	.	.	.	.	.	4	.	.	.	.	.	.	4
23	2	2	.	.	.	.	.	4	.	.	.	.	.	.	4
24	.	3	.	.	.	.	.	2	1	.	.	.	.	.	3
Total	23	5	.	.	.	.	.	27	1	.	.	.	.	.	28
Av. length	19	24	.	.	.	.	.	20	24	.	.	.	.	.	

FEMALES

Date November 19, 1929
St. No. W.S. Alongside Deception I.
Net N 100 B 0–5 m.
Locality Bransfield Strait
Surface T. circa 0·15° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
34	.	.	.	.	1	.	.	.	.	.	.	.	.	1	1
38	.	.	.	.	3	.		.	.	.	.	3	.	.	3
48	.	.	.	.	.	1	.	.	.	.	.	.	.	1	1
Total	.	.	.	.	4	1	.	.	.	.	.	3	.	2	5
Av. length	.	.	.	.	37	48	.	.	.	.	.	38	.	41	

Date November 13, 1930
St. No. 480
Net N 100 B 161–0 m.
N 70 V 1000–750 m.
Locality S. Georgia
Position 53° 40½′ S., 39° 54′ W
Surface T. 0·58° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
13	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
46	.	.	.	.	.	1	.	.	.	.	.	.	.	1	1
Total	1	.	.	.	.	1	.	1	.	.	.	.	.	1	2
Av. length	13	.	.	.	.	46	.	13	.	.	.	.	.	46	

Date November 16, 1930
St. No. 484
Net N 100 B 73–0 m.
Locality S. Georgia
Position 53° 52¼′ S., 37° 05½′ W
Surface T. −0·56° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
10	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
12	6	.	.	.	.	.	.	6	.	.	.	.	.	.	6
13	3	.	.	.	.	.	.	3	.	.	.	.	.	.	3
14	4	.	.	.	.	.	.	4	.	.	.	.	.	.	4
15	4	.	.	.	.	.	.	4	.	.	.	.	.	.	4
16	3	.	.	.	.	.	.	3	.	.	.	.	.	.	3
17	7	.	.	.	.	.	.	7	.	.	.	.	.	.	7
18	5	.	.	.	.	.	.	5	.	.	.	.	.	.	5
20	2	.	.	.	.	.	.	2	.	.	.	.	.	.	2
21	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
Total	36	.	.	.	.	.	.	36	.	.	.	.	.	.	36
Av. length	15	.	.	.	.	.	.	15	.	.	.	.	.	.	

Date November 18, 1930
St. No. 492
Net N 100 B 148–0 m.
Locality S. Georgia
Position 53° 12¾′ S., 37° 04¼′ W
Surface T. −0·35° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
14	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
15	6	.	.	.	.	.	.	6	.	.	.	.	.	.	6
16	4	.	.	.	.	.	.	4	.	.	.	.	.	.	4
17	2	.	.	.	.	.	.	2	.	.	.	.	.	.	2
18	2	.	.	.	.	.	.	2	.	.	.	.	.	.	2
19	4	.	.	.	.	.	.	4	.	.	.	.	.	.	4
20	6	.	.	.	.	.	.	6	.	.	.	.	.	.	6
21	2	.	.	.	.	.	.	2	.	.	.	.	.	.	2
22	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
23	2	.	.	.	.	.	.	2	.	.	.	.	.	.	2
Total	30	.	.	.	.	.	.	30	.	.	.	.	.	.	30
Av. length	18	.	.	.	.	.	.	18	.	.	.	.	.	.	

MALES

Date	November 19, 1930	Locality	S. Georgia
St. No.	494	Position	52° 50½′ S, 35° 35¾′ W
Net	N 100 B 160–0 m.	Surface T.	−0·85° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
33	.	.	.	1	.	.	.	.	.	.	1	.		.	1
35	.	.	.	.	.	1	.	.	.	.	.	.	.	1	1
38	.	.	.	1	.	.	.	.	.	.	.	1	.	.	1
39	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
40	.	.	.	1	.	1	2	.	.	.	.	.	1	3	4
41	.	.	.	.	1	.	1	.	.	.	.	.	1	1	2
42	.	.	.	.	.	.	3	.	.	.	.	.	.	3	3
43	.	.	.	.	.	.	2	.	.	.	.	.	.	2	2
44	.	.	.		.	1	1	.	.	.	.	.	.	2	2
45	.	.	.	.	.	.	6	.	.	.	.	.	.	6	6
46	.	.	.	.	.	.	4	.	.	.	.	.	.	4	4
47	.	.	.	.	.	.	2	.	.	.	.	.	.	2	2
48	.	.	.	.	.	.	4	.	.	.	.	.	.	4	4
51	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
52	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
55	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
Total	.	.	.	3	1	3	29	.	.	.	1	1	2	32	36
Av. length	.	.	.	37	41	40	45	.	.	.	33	38	41	45	

FEMALES

Date	November 19, 1930	Locality	S. Georgia
St. No.	494	Position	52° 50½′ S, 35° 35¾′ W
Net	N 100 B 160–0 m.	Surface T.	−0·85° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
36	.	.	.	.	1	.	.	.	.	.	.	1	.	.	1
37	.	.	.	.	2	.	.	.	.	.	.	1	.	1	2
38	.	.	.	.	2	.	.	.	.	.	.	2	.	.	2
39	.	.	.	.	2	.	.	.	.	.	.	2	.	.	2
40	.	.	.	.	7	.	.	.	.	.	.	6	.	1	7
41	.	.	.	.	3	.	.	.	.	.	.	3	.	.	3
42	.	.	.	.	6	.	.	.	.	.	.	5	.	1	6
43	.	.	.	.	8	.	.	.	.	.	.	5	1	2	8
44	.	.	.	.	7	.	.	.	.	.	.	3	.	4	7
45	.	.	.	.	8	.	.	.	.	.	.	5	.	3	8
46	.	.	.	.	5	.	.	.	.	.	.	1	1	3	5
47	.	.	.	.	3	.	.	.	.	.	.	.	1	2	3
48	.	.	.	.	1	.	.	.	.	.	.	.	1	.	1
49	.	.	.	.	5	.	.	.	.	.	.	1	4	.	5
51	.	.	.	.	1	.	.	.	.	.	.	.	1	.	1
Total	.	.	.	.	61	.	.	.	.	.	.	35	9	17	61
Av. length	.	.	.	.	43	.	.	.	.	.	.	42	48	44	

Date	November 29, 1930	Locality	S. Georgia
St. No.	523	Position	55° 08¾′ S, 37° 49¼′ W
Net	N 100 B N 70 B 157–0 m.	Surface T.	−0·30° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
18	2	.	.	.	.	.	.	2	.	.	.	.	.	.	2
19	4	.	.	.	.	.	.	4	.	.	.	.	.	.	4
20	15	.	.	.	.	.	.	15	.	.	.	.	.	.	15
21	16	.	.	.	.	.	.	16	.	.	.	.	.	.	16
22	12	.	.	.	.	.	.	12	.	.	.	.	.	.	12
23	8	.	.	.	.	.	.	8	.	.	.	.	.	.	8
24	10	.	.	.	.	.	.	10	.	.	.	.	.	.	10
25	10	.	.	.	.	.	.	10	.	.	.	.	.	.	10
26	3	.	.	.	.	.	.	3	.	.	.	.	.	.	3
27	9	.	.	.	.	.	.	9	.	.	.	.	.	.	9
28	5	.	.	.	.	.	.	5	.	.	.	.	.	.	5
30	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
Total	95	.	.	.	.	.	.	95	.	.	.	.	.	.	95
Av. length	23	.	.	.	.	.	.	23	.	.	.	.	.	.	

Date	November 29, 1930	Locality	S. Georgia
St. No.	523	Position	55° 08¾′ S, 37° 49¼′ W
Net	N 100 B 157–0 m.	Surface T.	−0·30° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
17	2	.	.	.	.	.	.	2	.	.	.	.	.	.	2
18	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
19	7	.	.	.	.	.	.	7	.	.	.	.	.	.	7
20	20	.	.	.	.	.	.	20	.	.	.	.	.	.	20
21	14	.	.	.	.	.	.	14	.	.	.	.	.	.	14
22	13	.	.	.	.	.	.	13	.	.	.	.	.	.	13
23	12	.	.	.	.	.	.	12	.	.	.	.	.	.	12
24	13	.	.	.	.	.	.	13	.	.	.	.	.	.	13
25	18	.	.	.	.	.	.	18	.	.	.	.	.	.	18
26	10	.	.	.	.	.	.	10	.	.	.	.	.	.	10
27	6	.	.	.	.	.	.	6	.	.	.	.	.	.	6
28	4	.	.	.	.	.	.	4	.	.	.	.	.	.	4
31	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
41	.	.	.	.	1	.	.	.	.	.	.	.	1	.	1
44	.	.	.	.	2	.	.	.	.	.	.	1	1	.	2
45	.	.	.	.	1	.	.	.	.	.	.	1	.	.	1
48	.	.	.	.	.	1	.	.	.	.	.	.	1	.	1
50	.	.	.	.	1	.	.	.	.	.	.	.	1	.	1
Total	121	.	.	.	5	1	.	121	.	.	.	2	4	.	127
Av. length	23	.	.	.	45	48	.	23	.	.	.	45	46	.	

Date	November 6, 1932	Locality	Bransfield Strait
St. No.	1009	Position	62° 55·9′ S, 58° 00·3′ W
Net	N 100 B 110–0 m.	Surface T.	−0·85° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
16	2	.	.	.	.	.	.	2	.	.	.	.	.	.	2
17	4	.	.	.	.	.	.	4	.	.	.	.	.	.	4
18	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
20	2	.	.	.	.	.	.	2	.	.	.	.	.	.	2
21	.	1	.	.	.	.	.	1	.	.	.	.	.	.	1
22	7	3	.	.	.	.	.	10	.	.	.	.	.	.	10
23	2	2	.	.	.	.	.	4	.	.	.	.	.	.	4
24	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
25	.	9	.	.	.	.	.	3	6	.	.	.	.	.	9
26	.	5	.	.	.	.	.	1	4	.	.	.	.	.	5
27	.	8	.	.	.	.	.	3	5	.	.	.	.	.	8
28	.	4	.	.	.	.	.	.	4	.	.	.	.	.	4
29	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
30	.	2	.	1	.	.	.	.	3	.	.	.	.	.	3
31	.	.	.	1	.	.	.	.	.	1	.	.	.	.	1
32	.	.	1	.	.	.	.	.	.	1	.	.	.	.	1
34	.	.	1	.	.	.	.	.	.	1	.	.	.	.	1
36	.	.	1	5	.	.	.	.	.	3	3	.	.	.	6
37	.	.	.	1	.	.	.	.	.	.	1	.	.	.	1
38	.	.	.	3	.	.	.	.	.	1	2	.	.	.	3
39	.	.	.	2	3	.	.	.	.	.	2	1	2	.	5
40	.	.	.	4	2	.	.	.	.	.	4	2	.	.	6
41	.	.	.	2	3	.	.	.	.	.	4	.	1	.	5
42	.	.	.	2	.	1	.	.	.	.	2	.	1	.	3
43	.	.	.	.	1	.	.	.	.	.	.	1	.	.	1
44	.	.	.	.	1	.	.	.	.	.	.	1	.	.	1
45	.	.	.	.	2	1	.	.	.	.	.	2	1	.	3
Total	19	35	3	21	12	2	.	32	23	7	18	7	5	.	92
Av. length	22	26	34	38	41	44	.	22	27	35	39	42	41	.	

Date	November 6, 1932	Locality	Bransfield Strait
St. No.	1009	Position	62° 55·9′ S, 58° 00·3′ W
Net	N 100 B 110–0 m.	Surface T.	−0·85° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
17	2	.	.	.	.	.	.	2	.	.	.	.	.	.	2
19	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
20	3	.	.	.	.	.	.	3	.	.	.	.	.	.	3
21	7	1	.	.	.	.	.	7	1	.	.	.	.	.	8
22	5	.	.	.	.	.	.	4	1	.	.	.	.	.	5
23	4	4	.	.	.	.	.	5	3	.	.	.	.	.	8
24	2	1	.	.	.	.	.	1	2	.	.	.	.	.	3
25	1	5	3	.	.	.	.	1	5	3	.	.	.	.	9
26	.	2	2	.	.	.	.	.	2	.	2	.	.	.	4
27	.	4	1	1	.	.	.	.	3	1	2	.	.	.	6
28	.	.	1	2	.	.	.	.	.	1	2	.	.	.	3
29	.	.	.	2	.	.	.	.	.	.	2	.	.	.	2
30	.	1	1	2	.	.	.	.	.	2	2	.	.	.	4
31	.	.	.	2	.	.	.	.	.	.	.	2	.	.	2
32	.	.	.	2	.	.	.	.	.	.	.	2	.	.	2
34	.	.	.	1	.	.	.	.	.	.	.	1	.	.	1
37	.	.	.	3	2	.	.	.	.	.	.	5	.	.	5
38	.	.	.	.	2	.	.	.	.	.	.	2	.	.	2
39	.	.	.	.	2	.	.	.	.	.	.	2	.	.	2
40	.	.	.	.	1	.	.	.	.	.	.	1	.	.	1
43	.	.	.	.	1	.	.	.	.	.	.	1	.	.	1
Total	25	18	8	15	8	.	.	24	17	7	10	16	.	.	74
Av length	21	25	27	31	39	.	.	21	25	27	28	36	.	.	

MALES

Date	December 7, 1926	Locality	S. Georgia
St. No.	Govt. Jetty, Grytviken	Surface T.	circa 4·65° C.
Net	N 100 H 0–1 m.		

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
25	2	2	.	.	.	.	.	2	2	.	.	.	.	.	4
26	1	.	.	.	.	.	.	.	1	.	.	.	.	.	1
27	.	2	.	.	.	.	.	1	1	.	.	.	.	.	2
28	4	3	.	.	.	.	.	3	4	.	.	.	.	.	7
29	2	6	.	.	.	.	.	3	5	.	.	.	.	.	8
30	.	3	.	.	.	.	.	.	3	.	.	.	.	.	3
31	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
32	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
34	.	2	.	.	.	.	.	.	2	.	.	.	.	.	2
Total	9	20	.	.	.	.	.	9	20	.	.	.	.	.	29
Av. length	27	29	.	.	.	.	.	28	29	.	.	.	.	.	

Date	December 11, 1926	Locality	S. Georgia
St. No.	King Edward's Cove	Surface T.	circa 4·65° C.
Net	N 100 H 0–1 m.		

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
23	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
25	2	.	.	.	.	.	.	.	2	.	.	.	.	.	2
26	1	1	.	.	.	.	.	1	1	.	.	.	.	.	2
27	4	4	.	.	.	.	.	3	5	.	.	.	.	.	8
28	1	2	.	.	.	.	.	.	3	.	.	.	.	.	3
29	1	3	.	.	.	.	.	.	4	.	.	.	.	.	4
30	2	1	.	.	.	.	.	1	2	.	.	.	.	.	3
31	1	3	.	.	.	.	.	.	4	.	.	.	.	.	4
32	.	7	.	.	.	.	.	.	7	.	.	.	.	.	7
33	.	3	1	1	.	.	.	.	4	1	.	.	.	.	5
34	.	3	.	.	.	.	.	.	3	.	.	.	.	.	3
35	.	2	2	.	.	.	.	.	4	.	.	.	.	.	4
36	.	1	2	.	.	.	.	.	3	.	.	.	.	.	3
37	.	.	1	.	.	.	.	.	1	.	.	.	.	.	1
38	.	.	.	1	.	.	.	.	1	.	.	.	.	.	1
39	.	.	1	.	.	.	.	.	1	.	.	.	.	.	1
Total	13	30	7	2	.	.	.	6	45	1	.	.	.	.	52
Av. length	27	31	36	35	.	.	.	27	31	33	.	.	.	.	

Date	December 19, 1926	Locality	S. Georgia
St. No.	125	Position	{53° 28′·30 S., {36° 20′·30 W
Net	N 100 H 70 m.	Surface T.	1·45° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
40	.	.	1	.	.	1	.	.	.	1	.	.	1	.	2
41	.	.	.	1	.	.	.	.	.	1	.	.	.	.	1
43	.	.	.	.	.	1	.	.	.	.	.	.	.	1	1
44	.	.	.	1	.	.	.	.	.	.	.	1	.	.	1
45	.	.	.	1	.	2	.	.	.	.	.	1	1	1	3
46	.	.	.	.	.	.	2	.	.	.	.	.	.	2	2
47	.	.	.	.	.	.	4	.	.	.	.	.	.	4	4
48	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
50	.	.	.	.	.	.	5	.	.	.	.	.	.	5	5
51	.	.	.	.	.	.	5	.	.	.	.	.	.	5	5
52	.	.	.	.	1	.	5	.	.	.	.	.	1	5	6
53	.	.	.	.	.	.	6	.	.	.	.	.	.	6	6
54	.	.	.	.	.	.	4	.	.	.	.	.	.	4	4
55	.	.	.	.	.	.	3	.	.	.	.	.	.	3	3
56	.	.	.	.	.	.	3	.	.	.	.	.	.	3	3
57	.	.	.	.	.	.	2	.	.	.	.	.	.	2	2
Total	.	.	1	3	1	4	40	.	.	2	.	2	3	42	49
Av. length	.	.	40	43	52	43	52	.	.	41	.	45	46	51	

Date	December 11, 1930	Locality	S. Georgia
St. No.	527	Position	{54° 09¼′ S., {34° 29½′ W
Net	N 450 H 122 (–0) m.	Surface T.	0·35° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
16	5	.	.	.	.	.	.	5	.	.	.	.	.	.	5
18	2	.	.	.	.	.	.	2	.	.	.	.	.	.	2
19	4	.	.	.	.	.	.	4	.	.	.	.	.	.	4
20	2	.	.	.	.	.	.	2	.	.	.	.	.	.	2
21	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
23	4	.	.	.	.	.	.	4	.	.	.	.	.	.	4
24	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
Total	19	.	.	.	.	.	.	19	.	.	.	.	.	.	19
Av. length	19	.	.	.	.	.	.	19	.	.	.	.	.	.	

FEMALES

Date	December 7, 1926	Locality	S. Georgia
St. No.	Govt. Jetty, Grytviken	Surface T.	circa 4·65° C.
Net	N 100 H 0–1 m.		

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
23	2	.	.	.	.	.	.	.	2	.	.	.	.	.	2
24	1	.	.	.	.	.	.	.	1	.	.	.	.	.	1
25	2	.	.	.	.	.	.	.	1	1	.	.	.	.	2
26	5	.	.	.	.	.	.	.	5	.	.	.	.	.	5
27	2	.	.	.	.	.	.	.	2	.	.	.	.	.	2
28	3	.	.	.	.	.	.	.	3	.	.	.	.	.	3
29	6	.	.	.	.	.	.	.	6	.	.	.	.	.	6
30	4	.	.	.	.	.	.	.	2	2	.	.	.	.	4
31	1	.	.	.	.	.	.	.	.	1	.	.	.	.	1
33	1	.	.	.	.	.	.	.	1	.	.	.	.	.	1
35	1	.	.	.	.	.	.	.	1	.	.	.	.	.	1
Total	28	.	.	.	.	.	.	.	24	4	.	.	.	.	28
Av. length	28	.	.	.	.	.	.	.	28	29	.	.	.	.	

Date	December 11, 1926	Locality	S. Georgia
St. No.	King Edward's Cove	Surface T.	circa 4·65° C.
Net	N 100 H 0–1 m.		

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
24	2	.	.	.	.	.	.	.	1	1	.	.	.	.	2
25	4	.	.	.	.	.	.	.	3	1	.	.	.	.	4
26	6	.	.	.	.	.	.	.	5	1	.	.	.	.	6
27	9	.	.	.	.	.	.	.	3	6	.	.	.	.	9
28	4	.	.	.	.	.	.	.	2	2	.	.	.	.	4
29	5	.	.	.	.	.	.	.	4	1	.	.	.	.	5
30	8	.	.	.	.	.	.	.	2	6	.	.	.	.	8
31	3	.	.	.	.	.	.	.	1	2	.	.	.	.	3
32	3	.	.	.	.	.	.	.	2	1	.	.	.	.	3
34	1	1	.	.	.	.	.	.	1	1	.	.	.	.	2
37	1	.	.	.	.	.	.	.	.	1	.	.	.	.	1
Total	46	1	.	.	.	.	.	.	24	23	.	.	.	.	47
Av. length	28	34	.	.	.	.	.	.	28	29	.	.	.	.	

Date	December 19, 1926	Locality	S. Georgia
St. No.	125	Position	{53° 28′ 30 S., {36° 20′ 30 W
Net	N 100 H 70 m.	Surface T.	1·45° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
43	.	.	.	1	.	.	.	.	.	.	.	1	.	.	1
44	.	.	.	.	1	.	.	.	.	.	.	.	.	1	1
45	.	.	.	.	3	.	.	.	.	.	.	1	1	1	3
46	.	.	.	.	1	.	.	.	.	.	.	.	.	1	1
47	.	.	.	.	1	.	.	.	.	.	.	.	.	1	1
48	.	.	.	.	2	.	.	.	.	.	.	1	.	1	2
49	.	.	.	.	4	.	.	.	.	.	.	1	.	3	4
50	.	.	.	.	4	1	.	.	.	.	.	1	.	4	5
51	.	.	.	.	2	.	.	.	.	.	.	.	.	2	2
52	.	.	.	.	2	1	.	.	.	.	.	1	.	2	3
54	.	.	.	.	6	.	.	.	.	.	.	1	.	5	6
55	.	.	.	.	4	9	.	.	.	.	.	.	2	11	13
56	.	.	.	.	1	2	.	.	.	.	.	.	.	3	3
57	.	.	.	.	1	.	1	.	.	.	.	.	.	2	2
58	.	.	.	.	1	.	.	.	.	.	.	.	1	.	1
60	.	.	.	.	.	1	.	.	.	.	.	.	.	1	1
61	.	.	.	.	.	.	1	.	.	.	.	.	1	.	1
Total	.	.	.	1	33	14	2	.	.	.	.	7	5	38	50
Av. length	.	.	.	43	51	55	59	.	.	.	.	48	55	53	

Date	December 11, 1930	Locality	S. Georgia
St. No.	527	Position	{54° 09¼′ S., {34° 29½′ W
Net	N 450 H 122 (–0) m.	Surface T.	0·35° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
14	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
15	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
16	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
17	3	.	.	.	.	.	.	3	.	.	.	.	.	.	3
18	4	.	.	.	.	.	.	4	.	.	.	.	.	.	4
19	4	.	.	.	.	.	.	4	.	.	.	.	.	.	4
20	4	.	.	.	.	.	.	4	.	.	.	.	.	.	4
21	2	.	.	.	.	.	.	2	.	.	.	.	.	.	2
22	3	.	.	.	.	.	.	3	.	.	.	.	.	.	3
24	3	.	.	.	.	.	.	2	1	.	.	.	.	.	3
26	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
28	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
42	.	.	.	.	.	1	.	.	.	.	.	.	.	1	1
Total	28	.	.	.	.	1	.	27	1	.	.	.	.	1	29
Av. length	20	.	.	.	.	42	.	20	24	.	.	.	.	42	

MALES

Date	December 13, 1930	Locality	S. Sandwich Is.
St. No.	530	Position	55° 32½′ S, 33° 14′ W
Net	N 100 B 168–0 m., 450–168 m.	Surface T.	−0·95° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
16	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
21	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
23	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
25	3	.	.	.	.	.	.	1	2	.	.	.	.	.	3
26	1	.	.	.	.	.	.	.	1	.	.	.	.	.	1
28	1	.	.	.	.	.	.	.	1	.	.	.	.	.	1
29	1	.	.	.	.	.	.	.	1	.	.	.	.	.	1
30	2	.	.	.	.	.	.	.	2	.	.	.	.	.	2
31	1	.	.	.	.	.	.	.	1	.	.	.	.	.	1
Total	12	.	.	.	.	.	.	4	8	.	.	.	.	.	12
Av. length	26	.	.	.	.	.	.	21	28	.	.	.	.	.	

Date	December 14, 1930	Locality	S. Sandwich Is.
St. No.	531	Position	57° 27′ S, 34° 25′ W
Net	N 100 B 164–0 m.	Surface T.	−0·90° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
25	1	.	.	.	.	.	.	.	1	.	.	.	.	.	1
27	1	.	.	.	.	.	.	.	1	.	.	.	.	.	1
30	1	.	.	.	.	.	.	.	1	.	.	.	.	.	1
Total	3	.	.	.	.	.	.	.	3	.	.	.	.	.	3
Av. length	27	.	.	.	.	.	.	.	27	.	.	.	.	.	

Date	December 17, 1930	Locality	S. Orkney Is.
St. No.	534	Position	60° 08′ S, 47° 53′ W
Net	N 100 B 172–0 m.	Surface T.	0·15° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
47	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
49	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
51	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
53	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
Total	.	.	.	.	.	.	4	.	.	.	.	.	.	4	4
Av. length	.	.	.	.	.	.	50	.	.	.	.	.	.	50	

Date	December 18, 1930	Locality	S. Orkney Is.
St. No.	535	Position	60° 13¼′ S, 50° 51½′ W
Net	N 70 B 0 m.	Surface T.	0·65° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
41	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
42	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
44	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
45	.	.	.	.	.	.	2	.	.	.	.	.	.	2	2
47	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
48	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
49	.	.	.	.	.	.	9	.	.	.	.	.	.	9	9
50	.	.	.	.	.	1	3	.	.	.	.	.	.	4	4
51	.	.	.	.	.	.	6	.	.	.	.	.	.	6	6
52	.	.	.	.	.	1	.	.	.	.	.	.	.	1	1
53	.	.	.	.	.	.	7	.	.	.	.	.	.	7	7
54	.	.	.	.	.	.	6	.	.	.	.	.	.	6	6
55	.	.	.	.	.	.	10	.	.	.	.	.	.	10	10
56	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
Total	.	.	.	.	.	2	49	.	.	.	.	.	.	51	51
Av. length	.	.	.	.	.	51	51	.	.	.	.	.	.	51	

Date	December 18, 1930	Locality	S. Orkney Is.
St. No.	536	Position	60° 43′ S, 52° 29½′ W
Net	N 100 B 122–0 m.	Surface T.	−0·30° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
35	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
42	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
50	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
51	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
54	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
55	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
Total	.	.	.	.	.	.	6	.	.	.	.	.	.	6	6
Av. length	.	.	.	.	.	.	48	.	.	.	.	.	.	48	

FEMALES

Date	December 13, 1930	Locality	S. Sandwich Is.
St. No.	530	Position	55° 32½′ S, 33° 14′ W
Net	N 100 B 168–0 m., 450–168 m.	Surface T.	−0·95° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
20	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
25	1	.	.	.	.	.	.	.	1	.	.	.	.	.	1
26	2	.	.	.	.	.	.	2	.	.	.	.	.	.	2
27	4	.	.	.	.	.	.	3	1	.	.	.	.	.	4
28	1	.	.	.	.	.	.	.	1	.	.	.	.	.	1
30	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
32	1	.	.	.	.	.	.	.	1	.	.	.	.	.	1
Total	11	.	.	.	.	.	.	7	4	.	.	.	.	.	11
Av. length	27	.	.	.	.	.	.	26	28	.	.	.	.	.	

Date	December 14, 1930	Locality	S. Sandwich Is.
St. No.	531	Position	57° 27′ S, 34° 25′ W
Net	N 100 B 164–0 m.	Surface T.	−0·90° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
21	2	.	.	.	.	.	.	2	.	.	.	.	.	.	2
22	2	.	.	.	.	.	.	1	1	.	.	.	.	.	2
24	2	.	.	.	.	.	.	2	.	.	.	.	.	.	2
25	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
Total	7	.	.	.	.	.	.	6	1	.	.	.	.	.	7
Av. length	23	.	.	.	.	.	.	23	22	.	.	.	.	.	

Date	December 17, 1930	Locality	S. Orkney Is.
St. No.	534	Position	60° 08′ S, 47° 53′ W
Net	N 100 B 172–0 m.	Surface T.	0·15° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
41	.	.	.	.	1	.	.	.	.	.	.	.	.	1	1
Total	.	.	.	.	1	.	.	.	.	.	.	.	.	1	1
Av. length	.	.	.	.	41	.	.	.	.	.	.	.	.	41	

Date	December 18, 1930	Locality	S. Orkney Is.
St. No.	535	Position	60° 13¼′ S, 50° 51½′ W
Net	N 70 B 0 m.	Surface T.	0·65° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
37	.	.	.	.	1	1	.	.	.	.	.	.	.	2	2
44	.	.	.	.	.	1	.	.	.	.	.	.	.	1	1
47	.	.	.	.	.	1	.	.	.	.	.	.	.	1	1
Total	.	.	.	.	1	3	.	.	.	.	.	.	.	4	4
Av. length	.	.	.	.	37	43	.	.	.	.	.	.	.	41	

Date	December 18, 1930	Locality	S. Orkney Is.
St. No.	536	Position	60° 43′ S, 52° 29½′ W
Net	N 100 B 122–0 m.	Surface T.	−0·30° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
36	.	.	.	.	1	.	.	.	.	.	.	.	.		1
Total	.	.	.	.	1	.	.	.	.	.	.	.	.	1	1
Av. length	.	.	.	.	36	.	.	.	.	.	.	.	.	36	

MALES

Date December 19, 1930
St. No. 537
Net N 100 B 137–0 m.
N 70 V 500–250 m.
Locality S. Shetland Is.
Position 61° 07½′ S., 54° 26′ W
Surface T. 0·01° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
17	6	.	.	.	.	.	.	6	.	.	.	.	.	.	6
19	6	.	.	.	.	.	.	6	.	.	.	.	.	.	6
20	24	.	.	.	.	.	.	24	.	.	.	.	.	.	24
21	24	.	.	.	.	.	.	24	.	.	.	.	.	.	24
22	18	.	.	.	.	.	.	18	.	.	.	.	.	.	18
23	18	.	.	.	.	.	.	18	.	.	.	.	.	.	18
24	42	.	.	.	.	.	.	42	.	.	.	.	.	.	42
25	36	18	.	.	.	.	.	36	18	.	.	.	.	.	54
27	12	.	.	.	.	.	.	6	6	.	.	.	.	.	12
28	6	.	.	.	.	.	.	.	6	.	.	.	.	.	6
31	6	.	.	.	.	.	.	.	6	.	.	.	.	.	6
44	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
49	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
Total	198	18	.	.	.	.	2	180	30	.	.	.	.	2	218
Av. length	23	25	.	.	.	.	47	23	27	.	.	.	.	47	

Date December 19, 1930
St. No. 538
Net N 100 B 137–0 m.
Locality S. Shetland Is.
Position 61° 29′ S., 54° 44¼′ W
Surface T. −0·25° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
17	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
18	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
19	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
20	2	.	.	.	.	.	.	2	.	.	.	.	.	.	2
21	2	.	.	.	.	.	.	1	1	.	.	.	.	.	2
22	3	.	.	.	.	.	.	2	1	.	.	.	.	.	3
24	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
27	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
46	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
50	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
53	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
56	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
Total	11	1	.	.	.	.	4	9	3	.	.	.	.	4	16
Av. length	21	27	.	.	.	.	51	21	23	.	.	.	.	51	

Date December 19, 1930
St. No. 539
Net N 70 B } 137–0 m.
N 100 B }
Locality S. Shetland Is.
Position 61° 48′ S., 54° 51½′ W
Surface T. −0·30° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
12	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
16	2	.	.	.	.	.	.	2	.	.	.	.	.	.	2
18	3	.	.	.	.	.	.	1	2	.	.	.	.	.	3
19	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
20	2	1	.	.	.	.	.	.	3	.	.	.	.	.	3
21	2	.	.	.	.	.	.	1	1	.	.	.	.	.	2
22	2	2	.	.	.	.	.	1	3	.	.	.	.	.	4
23	6	2	.	.	.	.	.	5	3	.	.	.	.	.	8
24	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
27	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
28	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
35	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
37	.	.	1	.	.	.	.	.	1	.	.	.	.	.	1
38	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
45	.	.	1	.	.	.	.	.	.	.	1	.	.	.	1
47	.	.	.	.	.	.	2	.	.	.	.	.	.	2	2
48	.	.	.	1	.	.	1	.	.	.	.	.	1	1	2
49	.	.	.	.	.	.	3	.	.	.	.	.	.	3	3
51	.	.	.	.	.	.	2	.	.	.	.	.	.	2	2
52	.	.	.	.	.	.	3	.	.	.	.	.	.	3	3
53	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
54	.	.	.	.	.	.	2	.	.	.	.	.	.	2	2
Total	20	7	2	1	.	.	16	13	15	.	1	.	1	16	46
Av. length	20	23	41	48	.	.	49	20	23	.	45	.	48	49	

FEMALES

Date December 19, 1930
St. No. 537
Net N 100 B 137–0 m.
N 70 V 500–250 m.
Locality S. Shetland Is.
Position 61° 07½′ S., 54° 26′ W
Surface T. 0·01° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
16	6	.	.	.	.	.	.	6	.	.	.	.	.	.	6
20	12	.	.	.	.	.	.	12	.	.	.	.	.	.	12
21	36	.	.	.	.	.	.	36	.	.	.	.	.	.	36
22	30	.	.	.	.	.	.	30	.	.	.	.	.	.	30
23	36	.	.	.	.	.	.	36	.	.	.	.	.	.	36
24	30	.	.	.	.	.	.	30	.	.	.	.	.	.	30
25	12	.	.	.	.	.	.	12	.	.	.	.	.	.	12
29	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
Total	163	.	.	.	.	.	.	163	.	.	.	.	.	.	163
Av. length	22	.	.	.	.	.	.	22	.	.	.	.	.	.	

Date December 19, 1930
St. No. 538
Net N 100 B 137–0 m.
Locality S. Shetland Is.
Position 61° 29′ S., 54° 44¼′ W
Surface T. −0·25° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
18	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
19	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
20	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
22	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
23	3	.	.	.	.	.	.	3	.	.	.	.	.	.	3
48	.	.	.	.	1	.	.	.	.	.	.	.	.	1	1
Total	7	.	.	.	1	.	.	7	.	.	.	.	.	1	8
Av. length	21	.	.	.	48	.	.	21	.	.	.	.	.	48	

Date December 19, 1930
St. No. 539
Net N 70 B } 137–0 m.
N 100 B }
Locality S. Shetland Is.
Position 61° 48′ S., 54° 51½′ W
Surface T. −0·30° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
12	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
17	2	.	.	.	.	.	.	2	.	.	.	.	.	.	2
18	4	.	.	.	.	.	.	4	.	.	.	.	.	.	4
19	2	.	.	.	.	.	.	2	.	.	.	.	.	.	2
20	4	.	.	.	.	.	.	4	.	.	.	.	.	.	4
21	9	.	.	.	.	.	.	9	.	.	.	.	.	.	9
22	6	.	.	.	.	.	.	6	.	.	.	.	.	.	6
23	.	1	.	.	.	.	.	1	.	.	.	.	.	.	1
28	.	.	1	.	.	.	.	.	1	.	.	.	.	.	1
30	.	1	.	.	1	.	.	.	1	.	.	.	.	1	2
31	.	.	.	.	2	.	.	.	.	.	.	1	1	.	2
32	.	.	.	.	.	3	.	.	.	.	.	2	1	.	3
35	.	.	.	.	1	1	.	.	.	.	.	.	1	1	2
36	.	.	.	.	.	1	.	.	.	.	.	.	1	.	1
37	.	.	.	.	.	1	.	.	.	.	.	.	1	.	1
38	.	.	.	1	.	4	.	.	.	.	1	.	1	3	5
39	.	.	.	.	.	2	.	.	.	.	.	.	1	1	2
40	.	.	.	.	.	1	.	.	.	.	.	.	1	.	1
41	.	.	.	.	2	.	.	.	.	.	.	.	2	.	2
42	.	.	.	.	.	4	.	.	.	.	.	.	3	1	4
43	.	.	.	.	.	1	.	.	.	.	.	.	1	.	1
44	.	.	.	.	1	.	.	.	.	.	.	.	1	.	1
45	.	.	.	.	.	1	.	.	.	.	.	.	1	.	1
46	.	.	.	.	.	1	.	.	.	.	.	1	.	.	1
47	.	.	.	.	1	.	.	.	.	.	.	.	1	.	1
48	.	.	.	.	.	1	.	.	.	.	.	.	.	1	1
50	.	.	.	.	.	1	.	.	.	.	.	.	.	1	1
51	.	.	.	.	.	1	.	.	.	.	.	.	.	1	1
52	.	.	.	.	.	2	.	.	.	.	.	.	.	2	2
55	.	.	.	.	.	.	2	.	.	.	.	.	.	2	2
Total	28	2	1	1	8	25	2	29	2	.	1	4	17	14	67
Av. length	20	27	28	38	38	41	55	20	29	.	38	35	40	45	

MALES

Date	December 19, 1930	Locality	S. Shetland Is.
St. No.	540	Position	62° 06¼′ S, 55° 08½′ W
Net	N 100 B 155–0 m. N 70 V 500–250 m.	Surface T.	−0·48° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
21	1			.	.			1					.		1
48	.				.		1	.						1	1
51				.			2				.	.	.	2	2
53	.				.	.	1	.		.	.	.	.	1	1
Total	1					.	4	1	.	.	.			4	5
Av. length	21		.				51	21						51	

Date	December 19–20, 1930	Locality	S. Shetland Is.
St. No.	541	Position	62° 22′ S, 55° 23′ W
Net	N 100 B 108–0 m.	Surface T.	−0·85° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
23	1	.	.	.	.	.	.	1	.	.	.	.	.		1
Total	1	.	.	.			.	1			.	.	.		1
Av. length	23	.	.	.	.	.	.	23	.	.	.	.	.	.	

Date	December 20, 1930	Locality	Bransfield Strait
St. No.	543	Position	62° 16′ S, 57° 20′ W
Net	N 100 B 178–0 m.	Surface T.	0·30° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
20	1	.	.	.		.	.	1	.	.	.	.	.	.	1
Total	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
Av. length	20	.	.	.	.	.	.	20	.	.	.	.	.	.	

Date	December 20, 1930	Locality	Bransfield Strait
St. No.	546	Position	62° 46¼′ S, 57° 11¼′ W
Net	N 100 B 164–0 m.	Surface T.	−0·60° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
48	.	.	.			.	1	.	.	.	.	.	.	1	1
53	.				.		1	.	.		.		.	1	1
Total	.	.	.			.	2	.	.	.	.	.	.	2	2
Av. length	.	.	.	.			51	.	.	.	.	.	.	51	

Date	December 20, 1930	Locality	Bransfield Strait
St. No.	547	Position	62° 59¼′ S, 57° 03′ W
Net	N 100 B 37–0 m.	Surface T.	−1·02° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
16	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
Total	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
Av. length	16	.	.	.	.	.	.	16	.	.	.	.	.	.	

FEMALES

Date	December 19, 1930	Locality	S. Shetland Is.
St. No.	540	Position	62° 06¼′ S, 55° 08½′ W
Net	N 100 B 155–0 m. N 70 V 500–250 m.	Surface T.	−0·48° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
20	2	.	.		.	.	.	2	.	.	.	.	.	.	2
32	.	.	.	.	1	.	.	.	.	.	.	.	.	1	1
34	.	.	.	.	.	1	.	.	.	.	.	.	.	1	1
Total	2	.	.	.	1	1	.	2	.	.	.	.	.	2	4
Av. length	20	.	.	.	32	34	.	20	.	.	.	.	.	33	

Date	December 19–20, 1930	Locality	S. Shetland Is.
St. No.	541	Position	62° 22′ S, 55° 23′ W
Net	N 100 B 108–0 m.	Surface T.	−0·85° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
18	1		.	.	.	.	.	1	.	.	.	.	.	.	1
19	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
21	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
23	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
25	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
27	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
32	.	.	.	.	1	.	.	.	.	.	.	.	.	1	1
44	.	.	.	.	.	1	.	.	.	.	.	.	.	1	1
Total	6	.	.	.	1	1	.	6	.	.	.	.	.	2	8
Av. length	22	.	.	.	32	48	.	22	.	.	.	.	.	38	

Date	December 20, 1930	Locality	Bransfield Strait
St. No.	543	Position	62° 16′ S, 57° 20′ W
Net	N 100 B 178–0 m.	Surface T.	0·30° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
15	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
Total	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
Av. length	15	.	.	.	.	.	.	15	.	.	.	.	.	.	

Date	December 20, 1930	Locality	Bransfield Strait
St. No.	546	Position	62° 46¼′ S, 57° 11¼′ W
Net	N 100 B 164–0 m.	Surface T.	−0·60° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
46	.	.	.	.	.	1	.	.	.	.	.	.	.	1	1
Total	.	.	.	.	.	1	.	.	.	.	.	.	.	1	1
Av. length	.	.	.	.	.	46	.	.	.	.	.	.	.	46	

Date	December 20, 1930	Locality	Bransfield Strait
St. No.	547	Position	62° 59¼′ S, 57° 03′ W
Net	N 100 B 37–0 m.	Surface T.	−1·02° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
20	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
Total	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
Av. length	20	.	.	.	.	.	.	20	.	.	.	.	.	.	

MALES

Date December 21, 1930
St. No. 548
Net N 100 B 102–0 m.
Locality Bransfield Strait
Position 62° 36¾′ S., 58° 58′ W
Surface T. 0·45° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
42	.	.	1	.	.	.	.	.		.	1	.	.		1
43	.	.	1	.	.	.	.	.	.	.	.	.	1		1
45	.	.	.	.	.	.	1	.	.		.	.		1	1
46	.	.	1	1	.	1	1	.	.	.	.		2	2	4
47	.	.	.	.	.	.	2	.	.	.	.	.	.	2	2
48	.	.	.	.	.	.	7	.	.	.	.		.	7	7
49	.	.	.	3	.	.	4	.	.	.	.		3	4	7
50	.	.	1	.	.	.	5	.	.	.	.		1	5	6
51	.	.	.	.	.	.	7	.	.	.	.	.	.	7	7
52	.	.		.	.	.	4	.	.	.		.	.	4	4
53	.	.	.	.	.	.	2	.	.	.	.	.	.	2	2
54	.	.	.		.	.	1	.	.	.	.	.	.	1	1
Total	.	.	4	4	.	1	34	.	.	.	1	.	7	35	43
Av. length	.	.	45	48	.	46	50	.	.	.	42	.	47	50	

Date December 21–22, 1930
St. No. 549
Net N 100 B 115–0 m.
Locality Bransfield Strait
Position 63° 00¼′ S., 61° 16½′ W
Surface T. 0·41° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
18	1	.	.	.	.	.	.	1		.	.	.	.	.	1
19	1	.	.	.	.	.	.	1		.	.	.	.	.	1
21	3	.	.	.	.	.	.	3		.	.	.	.	.	3
22	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
23	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
31	.	1	.	.	.	.	.	.	.	1	.	.	.	.	1
32	.	1	.	1	.	.	.	.	2	.	.	.	.	.	2
33	.	1	1	.	.	.	.	.	2	.	.	.	.	.	2
35	.	.	.	1	.	.	.	.		1	.	.	.	.	1
36	.	2	.	.	.	.	.	.	1	1	.	.	.	.	2
37	.	.	2	2	.	.	.	.	1	1	2	.	.	.	4
38	.	.	1	.	.	.	.	.	1	.	.	.	.	.	1
39	.	1	.	.	.	.	.	.	.	1	.	.	.	.	1
40	.	.	1	1	.	.	.	.	.	1	1	.	.	.	2
41	.	.	1	3	.	.	.	.		1	3	.	.	.	4
42	.	.	1	4	.	.	.	.	.	.	4	1	.	.	5
43	.	.	1	1		.	.	.	.		2		.		2
44	.	.	.	.	1	.	1	.	.	.	.	1	.	1	2
45	.	.	.	2	.	.			.		1	1		.	2
46	.	.	.	.	1	.	1		.	.		.	1	1	2
47	.	.	.	.	1	.	.	.	.		.	.	1		1
48	.	.	1	.	.	.	1	.	.	.	1	.		1	2
Total	7	6	9	15	3	.	3	7	7	7	14	3	2	3	43
Av. length	21	35	40	40	46	.	46	21	34	37	42	44	47	46	

Date December 29, 1930
St. No. 558
Net N 100 B 146–0 m.
Locality Bellingshausen Sea
Position 65° 31′ S., 67° 07¼′ W
Surface T. –0·92° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
49	.	.	.	1	.	.	.	.	.	.	.	.	1		1
52	.	.	.	.	.	.	1	.	.	.	.	.		1	1
Total	.	.	.	1	.	.	1	.	.	.	.	.	1	1	2
Av. length	.	.	.	49	.	.	52	.	.	.	.	.	49	52	

Date December 30, 1930
St. No. 559
Net N 100 B 113–0 m.
Locality Bellingshausen Sea
Position 66° 21¾′ S., 68° 55½′ W
Surface T. 0·81° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
40	.	.	.	1	.	.	.	.	.	.	1	.	.	.	1
47	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
Total	.	.	.	1	.	.	1	.	.	.	1		.	1	2
Av. length	.	.	.	40	.	.	47	.	.	.	40	.	.	47	

FEMALES

Date December 21, 1930
St. No. 548
Net N 100 B 102–0 m.
Locality Bransfield Strait
Position 62° 36¾′ S., 58° 58′ W
Surface T. 0·45° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
39				1	1							2			2
40					4							4			4
41					2						.	1		1	2
43					4	1						2		3	5
45					5	1						2	1	3	6
46					1							1			1
47	.			.	3								2	1	3
48	.	.			5								4	1	5
49					2								2	.	2
50					3									3	3
52						1							1	.	1
53					1								1	.	1
55					1								1	.	1
Total				1	32	3	.		.			12	12	12	36
Av. length				39	46	47						42	49	46	

Date December 21–22, 1930
St. No. 549
Net N 100 B 115–0 m.
Locality Bransfield Strait
Position 63° 00¼′ S., 61° 16½′ W
Surface T. 0·41° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
13	1		.					1		.					1
15	1		.					1							1
17	1	.						1							1
18	1	.	.					1						.	1
19	1	.						1						.	1
21	1	.	.					1							1
32	.	1	.			.		.		1		.		.	1
33	.	1		2				.		1	1	1			3
35	.	.	.	1	.							1		.	1
36	.	2	.	1	1				1		1	2		.	4
37	.		.		3				.			3		.	3
38			.		2						1	1			2
39		.	.	1	2							3	.		3
40	.	.		.	3	.						3	.	.	3
41	.	.	.	.	2	.					.	2	.		2
42	.	.	.	.	1	.						1	.	.	1
43	.	.	.	1		.		.					.	1	1
44	.	.	.	1	2	.		.			.	2	.	1	3
45	.	.		.	3			.		.	.	1	1	1	3
46	.	.		.	1		.	.				.		1	1
47	.	.	.		1		.	.				1	.		1
48	.	.			1		.	.			.	.		1	1
52	.	.			2		.	.					.	2	2
Total	6	4		7	24	.	.	6	1	2	3	21	1	7	41
Av. length	17	34	.	38	42	.		17	36	33	36	40	45	47	

Date December 29, 1930
St. No. 558
Net N 100 B 146–0 m.
Locality Bellingshausen Sea
Position 65° 31′ S., 67° 07¼′ W
Surface T. –0·92° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
22	1	.	.				.	1	.				.	.	1
23	1	.	.	.		.	.	1						.	1
25	1	.						1						.	1
40	.	.			3		.					3		.	3
Total	3	.	.		3	.		3				3		.	6
Av. length	27	.	.	.	40			27				40		.	

Date December 30, 1930
St. No. 559
Net N 100 B 113–0 m.
Locality Bellingshausen Sea
Position 66° 21¾′ S., 68° 55½′ W
Surface T. –0·81° C.

Length in mm.	Stages														Total in sample
		2	3	4	5	6	7	A	B	C	D	E	F	G	
22	1	.	.	.	.		.		1				.		1
33	.	.	.	.	1	.	.				.	1	.		1
43	.	.	.	.	1			.	.			.		1	1
45	.	.	.	.	1	.	.	.	.		.		1	.	1
46	.	.		.	1				.		.	.	1	.	1
47	.	.			1			.	.		.	.		1	1
Total	1	.			5		.		1	.	.	1	2	2	9
Av. length	22	.	.		43	.		.	22		.	33	46	45	

MALES

Date December 30, 1930
St. No. 560
Net N 100 B 155–0 m.
Locality Bellingshausen Sea
Position {66° 47¼′ S, 69° 19′ W
Surface T. −0·69° C.

Length in mm.	Stages 1	2	3	4	5	6	7	A	B	C	D	E	F	G	Total in sample
29	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
49	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
Total	1	.	.	.	.	.	1	1	.	.	.	.	.	1	2
Av. length	29	.	.	.	.	.	49	29	.	.	.	.	.	49	

FEMALES

Date December 30, 1930
St. No. 560
Net N 100 B 155–0 m
Locality Bellingshausen Sea
Position {66° 47¼′ S, 69° 19′ W
Surface T. −0·69° C.

Length in mm.	Stages 1	2	3	4	5	6	7	A	B	C	D	E	F	G	Total in sample
30	.	1	.	.	.	.	.	1	.	.	.	.	.	.	1
37	.	.	.	1	.	.	.	.	.	.	.	1	.	.	1
42	.	.	.	1	.	.	.	.	.	.	.	1	.	.	1
45	.	.	.	.	1	.	.	.	.	.	.	.	.	1	1
47	.	.	.	.	1	.	.	.	.	.	.	.	.	1	1
50	.	.	.	.	.	1	.	.	.	.	.	.	.	1	1
Total	.	1	.	2	2	1	.	1	.	.	.	2	.	3	6
Av. length	.	20	.	40	46	50	.	20	.	.	.	40	.	47	

Date December 31, 1930
St. No. 561
Net N 100 B 137–0 m.
Locality Bellingshausen Sea
Position {66° 47¼′ S, 72° 09¼′ W
Surface T. −1·35° C.

Length in mm.	Stages 1	2	3	4	5	6	7	A	B	C	D	E	F	G	Total in sample
52	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
Total	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
Av. length	.	.	.	.	.	.	52	.	.	.	.	.	.	52	

Date December 31, 1930
St. No. 561
Net N 100 B 137–0 m.
Locality Bellingshausen Sea
Position {66° 47¼′ S, 72° 09¼′ W
Surface T. −1·35° C.

Length in mm.	Stages 1	2	3	4	5	6	7	A	B	C	D	E	F	G	Total in sample
47	.	.	.	.	1	.	.	.	.	.	.	1	.	.	1
50	.	.	.	.	.	1	.	.	.	.	.	.	.	1	1
Total	.	.	.	.	1	1	.	.	.	.	.	1	.	1	2
Av. length	.	.	.	.	47	50	.	.	.	.	.	47	.	50	

Date December 31, 1930
St. No. 562
Net N 100 B 113–0 m.
Locality Bellingshausen Sea
Position {67° 15½′ S, 75° 27′ W
Surface T. −0·62° C.

Length in mm.	Stages 1	2	3	4	5	6	7	A	B	C	D	E	F	G	Total in sample
48	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
Total	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
Av. length	.	.	.	.	.	.	48	.	.	.	.	.	.	48	

Date December 31, 1930
St. No. 562
Net N 100 B 113–0 m.
Locality Bellingshausen Sea
Position {67° 15½′ S, 75° 27′ W
Surface T. −0·62° C.

Length in mm.	Stages 1	2	3	4	5	6	7	A	B	C	D	E	F	G	Total in sample
53	.	.	.	.	.	1	.	.	.	.	.	.	.	1	1
Total	.	.	.	.	.	1	.	.	.	.	.	.	.	1	1
Av. length	.	.	.	.	.	53	.	.	.	.	.	.	.	53	

MALES

Date January 22, 1929
St. No. WS 373 EE
Net N 100 B 70–0 m.
Locality S. Georgia
Position 54° 10′ S., 35° 40′ W
Surface T. circa 2·99° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
36	.	.	1	.	.	.	.	.	1	.	.	.	.	.	1
37	.	.	1	.	.	.	.	.	1	.	.	.	.	.	1
38	.	.	1	.	.	.	.	.	1	.	.	.	.	.	1
42	.	.	1	.	.	.	.	.	.	.	1	.	.	.	1
43	.	1	1	.	.	.	.	.	.	.	2	.	.	.	2
44	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
45	.	.	2	.	.	.	.	.	.	.	.	2	.	.	2
46	.	.	1	.	.	.	3	.	.	.	.	1	.	3	4
47	.	.	.	1	.	.	3	.	.	.	.	1	.	3	4
48	.	.	1	.	.	.	2	.	.	.	.	1	.	2	3
49	.	.	2	.	.	.	.	.	.	.	.	2	.	.	2
50	.	.	.	.	.	.	5	.	.	.	.	.	.	5	5
51	.	.	.	.	.	.	3	.	.	.	.	.	.	3	3
52	.	.	1	.	.	.	3	.	.	.	.	1	.	3	4
53	.	.	.	.	.	.	6	.	.	.	.	.	.	6	6
54	.	.	.	.	.	.	2	.	.	.	.	.	.	2	2
55	.	.	1	.	.	.	3	.	.	.	.	1	.	3	4
56	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
58	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
Total	.	1	13	1	.	.	33	.	3	.	3	9	.	33	48
Av. length	.	43	45	47	.	.	51	.	37	.	43	48	.	51	

FEMALES

Date January 22, 1929
St. No. WS 373 EE
Net N 100 B 70–0 m.
Locality S. Georgia
Position 54° 10′ S., 35° 40′ W
Surface T. circa 2·99° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
33	1	.	.	.	.	.	.	.	1	.	.	.	.	.	1
34	1	.	.	.	.	.	.	1	.	.	.	.	.		1
36	.	2	.	.	.	.	.	.	2	.	.	.	.	.	2
45	.	.	.	.	1	1	.	.	.	.	.	.	1	1	2
47	.	.	.	.	.	1	.	.	.	.	.	.	.	1	1
48	.	.	.	.	.	1	.	.	.	.	.	.	.	1	1
49	.	.	.	.	.	6	.	.	.	.	.	.	1	5	6
50	.	.	.	.	.	3	1*	.	.	.	.	.	.	4	4
51	.	.	.	.	.	10	.	.	.	.	.	.	1	9	10
52	.	.	.	.	.	6	.	.	.	.	.	.	1	5	6
53	.	.	.	.	.	2	2	.	.	.	.	.	2	2	4
54	.	.	.	.	.	7	.	.	.	.	.	.	1	6	7
55	.	.	.	.	.	2	.	.	.	.	.	.	.	2	2
56	.	.	.	.	.	1	.	.	.	.	.	.	.	1	1
57	.	.	.	.	.	1	.	.	.	.	.	.	.	1	1
58	.	.	.	.	.	1	.	.	.	.	.	.	.	1	1
59	.	.	.	.	.	1	.	.	.	.	.	.	1	.	1
Total	2	2	.	.	1	43	3	1	3	.	.	.	8	39	51
Av. length	34	36	.	.	45	52	52	34	35	.	.	.	52	52	

Date January 21–22, 1930
St. No. 305
Net N 100 B 100–0 m.
Locality S. Georgia
Position 53° 17′ S., 37° 10′ W
Surface T. 3·30° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
35	.	2	1	.	.	.	.	.	3	.	.	.	.	.	3
36	.	1	1	.	.	.	.	.	2	.	.	.	.	.	2
37	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
38	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
41	.	2	1	.	.	.	.	.	3	.	.	.	.	.	3
42	.	.	1	.	.	.	.	.	1	.	.	.	.	.	1
45	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
51	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
54	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
57	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
Total	.	8	4	.	.	.	3	.	12	.	.	.	.	3	15
Av. length	.	39	39	.	.	.	54	.	39	.	.	.	.	54	

Date January 21–22, 1930
St. No. 305
Net N 100 B 100–0 m.
Locality S. Georgia
Position 53° 17′ S., 37° 10′ W
Surface T. 3·30° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
37	1	.	.	.	.	.	.	.	.	1	.	.	.	.	1
38	1	.	.	.	.	.	.	.	1	.	.	.	.	.	1
39	1	.	.	.	.	.	.	.	1	.	.	.	.	.	1
40	1	.	.	.	.	.	.	.	1	.	.	.	.	.	1
41	1	.	.	.	.	.	.	.	1	.	.	.	.	.	1
42	2	.	.	.	.	.	.	.	.	2	.	.	.	.	2
45	1	.	.	.	.	.	.	.	.	1	.	.	.	.	1
50	.	.	.	.	.	1	.	.	.	.	.	.	.	1	1
51	.	.	.	.	.	1	.	.	.	.	.	.	.	1	1
Total	8	.	.	.	.	2	.	.	4	4	.	.	.	2	10
Av. length	41	.	.	.	.	51	.	.	40	42	.	.	.	51	

Date January 24–25, 1930
St. No. 312
Net N 100 B 150–0 m.
N 70 V {100–50 m. / 550–250 m.
Locality S. Georgia
Position 53° 39¼′ S., 35° 37½′ W
Surface T. 2·45° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
35	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
41	.	.	1	.	.	.	.	.	.	1	.	.	.	.	1
45	.	.	1	.	.	.	.	.	.	.	1	.	.	.	1
47	.	.	1	.	.	.	.	.	.	.	1	.	.	.	1
50	.	.	.	.	.	.	2	.	.	.	.	.	.	2	2
51	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
52	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
53	.	.	.	.	.	.	11	.	.	.	.	.	.	11	11
54	.	.	.	.	.	.	3	.	.	.	.	.	.	3	3
55	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
56	.	.	.	.	.	.	2	.	.	.	.	.	.	2	2
57	.	.	.	.	.	.	4	.	.	.	.	.	.	4	4
Total	.	1	3	.	.	.	25	.	1	1	2	.	.	25	29
Av. length	.	35	44	.	.	.	54	.	35	41	46	.	.	54	

Date January 24–25, 1930
St. No. 312
Net N 100 B 150–0 m.
N 70 V 100–50 m.
Locality S. Georgia
Position 53° 39¼′ S., 35° 37½′ W
Surface T. 2·45° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
30	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
50	.	.	.	.	.	.	1*	.	.	.	.	.	.	1	1
51	.	.	.	.	1	.	.	.	.	.	.	.	1	.	1
57	.	.	.	.	.	.	1*	.	.	.	.	.	.	1	1
62	.	.	.	.	.	.	1*	.	.	.	.	.	1	.	1
Total	1	.	.	.	1	.	3	1	.	.	.	.	2	2	5
Av. length	30	.	.	.	51	.	56	30	.	.	.	.	57	54	

Date January 29, 1930
St. No. 318
Net N 100 B 104–0 m.
Locality S. Georgia
Position 53° 39′ S., 38° 24½′ W
Surface T. 3·10° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
36	.	.	2	.	.	.	.	.	2	.	.	.	.	.	2
37	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
39	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
43	.	.	1	.	.	.	.	.	.	1	.	.	.	.	1
Total	.	2	3	.	.	.	.	.	4	1	.	.	.	.	5
Av. length	.	38	38	.	.	.	.	.	37	43	.	.	.	.	

Date January 29, 1930
St. No. 318
Net N 100 B 104–0 m.
Locality S. Georgia
Position 53° 39′ S., 38° 24½′ W
Surface T. 3·10° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
37	4	.	.	.	.	.	.	.	2	2	.	.	.	.	4
39	1	.	.	.	.	.	.	.	1	.	.	.	.	.	1
40	2	.	.	.	.	.	.	.	1	1	.	.	.	.	2
Total	7	.	.	.	.	.	.	.	4	3	.	.	.	.	7
Av. length	38	.	.	.	.	.	.	.	38	38	.	.	.	.	

NOTE. Females marked with an asterisk have spawned.

MALES

Date January 8, 1931
St. No. 575
Net N 100 B 97–0 m.
Locality Bellingshausen Sea
Position 67° 53¼′ S., 91° 23′ W
Surface T. −1·47° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
31	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
33	.	1	.	1	.	.	.	.	1	1	.	.	.	.	2
34	.	.	2	.	.	.	.	.	1	1	.	.	.	.	2
36	.	.	.	1	.	.	.	.	.	1	.	.	.	.	1
37	.	.	.	2	.	.	.	.	.	1	1	.	.	.	2
38	.	.	.	1	.	.	.	.	.	.	1	.	.	.	1
40	.	.	.	.	1	.	.	.	.	.	1	.	.	.	1
41	.	.	.	1	2	.	.	.	.	1	2	.	.	.	3
45	.	.	.	.	1	.	.	.	.	.	.	1	.	.	1
46	.	.	.	.	1	.	2	.	.	.	1	.	.	2	3
47	.	.	.	.	1	.	1	.	.	.	.	1	.	1	2
48	.	.	.	.	.	1	1	.	.	.	.	.	1	1	2
50	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
Total	.	2	2	6	6	1	5	.	3	5	6	2	1	5	22
Av. length	.	32	34	37	43	48	47	.	33	36	41	46	48	47	

Date January 8, 1931
St. No. 576
Net N 100 B 132–0 m.
Locality Bellingshausen Sea
Position 67° 50′ S., 89° 12¾′ W
Surface T. −1·15° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
49	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
Total	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
Av. length	.	.	.	.	.	.	49	.	.	.	.	.	.	49	

Date January 9, 1931
St. No. 578
Net N 100 B 128–0 m.
Locality Bellingshausen Sea
Position 67° 54′ S., 81° 26¾′ W
Surface T. −1·20° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
21	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
28	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
50	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
Total	2	.	.	.	.	.	1	2	.	.	.	.	.	1	3
Av. length	25	.	.	.	.	.	50	25	.	.	.	.	.	50	

Date January 10, 1931
St. No 580
Net N 100 B 128–0 m.
Locality Bellingshausen Sea
Position 67° 41½′ S., 75° 56½′ W
Surface T. −0·10° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
24	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
46	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
47	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
48	.	.	.	.	.	.	2	.	.	.	.	.	.	2	2
50	.	.	.	.	.	.	4	.	.	.	.	.	.	4	4
51	.	.	.	.	.	.	3	.	.	.	.	.	.	3	3
52	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
53	.	.	.	.	.	.	4	.	.	.	.	.	.	4	4
54	.	.	.	.	.	.	5	.	.	.	.	.	.	5	5
Total	1	.	.	.	.	.	21	1	.	.	.	.	.	21	22
Av. length	24	.	.	.	.	.	51	24	.	.	.	.	.	51	

FEMALES

Date January 8, 1931
St. No. 575
Net N 100 B 97–0 m.
Locality Bellingshausen Sea
Position 67° 53¼′ S., 91° 23′ W
Surface T. −1·47° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
30	1	.	.	.	.	.	.	.	.	1	.	.	.	.	1
31	1	1	.	.	1	.	.	.	1	1	1	.	.	.	3
33	.	1	.	.	1	.	.	.	.	1	.	.	.	1	2
34	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
35	.	.	.	.	2	.	.	.	.	.	.	.	.	2	2
36	.	.	.	.	1	.	.	.	.	.	.	.	.	1	1
37	.	.	.	.	4	.	.	.	.	.	1	.	1	2	4
38	.	.	.	.	1	1	.	.	.	.	.	.	.	2	2
39	.	.	.	.	3	.	.	.	.	.	.	.	.	3	3
40	.	.	.	.	3	1	.	.	.	.	.	.	2	2	4
41	.	.	.	.	.	1	.	.	.	.	.	.	.	1	1
42	.	.	.	.	2	.	.	.	.	.	.	.	.	2	2
43	.	.	.	.	3	.	.	.	.	.	.	1	1	1	3
44	.	.	.	.	2	2	.	.	.	.	.	.	.	4	4
45	.	.	.	.	2	2	.	.	.	.	.	.	1	3	4
46	.	.	.	.	1	1	.	.	.	.	.	.	1	1	2
47	.	.	.	.	.	1	.	.	.	.	.	.	.	1	1
48	.	.	.	.	1	3	.	.	.	.	.	.	.	4	4
49	.	.	.	.	.	3	.	.	.	.	.	.	1	2	3
Total	2	3	.	.	27	15	.	.	2	3	2	1	7	32	47
Av. length	31	33	.	.	39	45	.	.	33	31	34	43	43	42	

Date January 8, 1931
St. No. 576
Net N 100 B 132–0 m.
Locality Bellingshausen Sea
Position 67° 50′ S., 89° 12¾′ W
Surface T. −1·15° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
47	.	.	.	.	.	1	.	.	.	.	.	.	.	1	1
Total	.	.	.	.	.	1	.	.	.	.	.	.	.	1	1
Av. length	.	.	.	.	.	47	.	.	.	.	.	.	.	47	

Date January 9, 1931
St. No. 578
Net N 100 B 128–0 m.
Locality Bellingshausen Sea
Position 67° 54′ S., 81° 26¾′ W
Surface T. −1·20° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
22	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
Total	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
Av. length	22	.	.	.	.	.	.	22	.	.	.	.	.	.	

Date January 10, 1931
St. No. 580
Net N 100 B 128–0 m.
Locality Bellingshausen Sea
Position 67° 41½′ S., 75° 56½′ W
Surface T. −0·10° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
45	.	.	.	.	.	1	.	.	.	.	.	.	.	1	1
48	.	.	.	.	.	1	.	.	.	.	.	.	.	1	1
Total	.	.	.	.	.	2	.	.	.	.	.	.	.	2	2
Av. length	.	.	.	.	.	47	.	.	.	.	.	.	.	47	

MALES

Date January 10, 1931
St. No. Marine Station Jetty
Net NH 0 m.
Locality S. Georgia
Surface T. 2·40 C. (?)

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
19	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
20	12	.	.	.	.	.	.	12	.	.	.	.	.	.	12
21	30	.	.	.	.	.	.	30	.	.	.	.	.	.	30
22	26	.	.	.	.	.	.	26	.	.	.	.	.	.	26
23	27	.	.	.	.	.	.	27	.	.	.	.	.	.	27
24	25	.	.	.	.	.	.	25	.	.	.	.	.	.	25
25	26	2	.	.	.	.	.	26	2	.	.	.	.	.	28
26	12	1	.	.	.	.	.	12	1	.	.	.	.	.	13
27	3	1	.	.	.	.	.	3	1	.	.	.	.	.	4
28	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
30	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
31	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
Total	163	6	.	.	.	.	.	163	6	.	.	.	.	.	169
Av. length	23	27	.	.	.	.	.	23	27	.	.	.	.	.	

Date January 12, 1931
St. No 583
Net N 100 B 139–0 m.
Locality Bellingshausen Sea
Position {67 18¼′ S,
69 53′ W
Surface T. −0·19 C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
51	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
Total	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
Av. length	.	.	.	.	.	.	51	.	.	.	.	.	.	51	

Date January 13, 1931
St. No. 584
Net N 100 B 165–0 m.
Locality Bellingshausen Sea
Position {67 26¾′ S,
69 35¼′ W
Surface T. −0·72 C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
46	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
Total	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
Av. length	.	.	.	.	.	.	46	.	.	.	.	.	.	46	

Date January 14, 1931
St. No. 590
Net N 100 B {90–0 m.
310–0 m.
N 70 B 90–0 m.
Locality Bellingshausen Sea
Position {65 20½′ S,
73 30½′ W
Surface T. 1·57 C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
49	.	.	.	.	1	.	1	.	.	.	.	.	1	1	2
50	.	.	.	.	.	.	2	.	.	.	.	.	.	2	2
52	.	.	.	.	.	.	2	.	.	.	.	.	.	2	2
54	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
55	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
Total	.	.	.	.	1	.	7	.	.	.	.	.	1	7	8
Av. length	.	.	.	.	49	.	52	.	.	.	.	.	49	52	

Date January 16, 1931
St. No. 596
Net N 100 B }
N 70 B } 170–0 m.
Locality Bellingshausen Sea
Position {65 31′ S,
68 55½′ W
Surface T. 1·51 C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
45	.	.	.	1	.	.	.	.	.	.	.	.	1	.	1
47	.	.	.	1	.	.	.	.	.	.	1	.	.	.	1
48	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
49	.	.	.	.	1	.	.	.	.	.	.	.	1	.	1
50	.	.	.	.	.	.	2	.	.	.	.	.	.	2	2
51	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
52	.	.	.	.	1	.	1	.	.	.	.	.	1	1	2
53	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
Total	.	.	.	2	2	.	6	.	.	.	1	.	3	6	10
Av. length	.	.	.	46	51	.	51	.	.	.	47	.	49	51	

FEMALES

Date January 10, 1931
St. No. Marine Station Jetty
Net NH 0 m
Locality S. Georgia
Surface T. 2·40 C. (?)

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
18	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
20	17	.	.	.	.	.	.	17	.	.	.	.	.	.	17
21	25	.	.	.	.	.	.	25	.	.	.	.	.	.	25
22	24	.	.	.	.	.	.	24	.	.	.	.	.	.	24
23	41	.	.	.	.	.	.	41	.	.	.	.	.	.	41
24	30	.	.	.	.	.	.	30	.	.	.	.	.	.	30
25	13	.	.	.	.	.	.	13	.	.	.	.	.	.	13
26	3	.	.	.	.	.	.	1	2	.	.	.	.	.	3
29	1	.	.	.	.	.	.	.	1	.	.	.	.	.	1
30	1	.	.	.	.	.	.	.	1	.	.	.	.	.	1
Total	156	.	.	.	.	.	.	152	4	.	.	.	.	.	156
Av. length	23	.	.	.	.	.	.	23	28	.	.	.	.	.	

Date January 12, 1931
St. No. 583
Net N 100 B 139–0 m.
Locality Bellingshausen Sea
Position {67 18¼′ S,
69 53′ W
Surface T. −0·19 C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
25	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
38	.	.	.	.	1	.	.	.	.	.	1	.	.	.	1
48	.	.	.	.	1	.	.	.	.	.	.	.	1	.	1
Total	1	.	.	.	2	.	.	1	.	.	1	.	1	.	3
Av. length	25	.	.	.	43	.	.	25	.	.	38	.	48	.	

Date January 13 1931
St. No. 584
Net N 100 B 165–0 m.
Locality Bellingshausen Sea
Position {67 26¼′ S,
69 35¼′ W
Surface T. −0·72 C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
23	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
48	.	.	.	.	.	1	.	.	.	.	.	.	.	1	1
Total	1	.	.	.	.	1	.	1	.	.	.	.	.	1	2
Av. length	23	.	.	.	.	48	.	23	.	.	.	.	.	48	

Date January 14, 1931
St. No. 590
Net N 100 B 90–0 m.
Locality Bellingshausen Sea
Position {65° 20½′ S,
73 30½′ W
Surface T. 1·57 C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
48	.	.	.	.	.	1	.	.	.	.	.	.	.	1	1
50	.	.	.	.	.	1	.	.	.	.	.	.	.	1	1
Total	.	.	.	.	.	2	.	.	.	.	.	.	.	2	2
Av. length	.	.	.	.	.	49	.	.	.	.	.	.	.	49	

Date January 16, 1931
St. No. 596
Net N 100 B 170–0 m.
Locality Bellingshausen Sea
Position {65° 31′ S,
68 55½′ W
Surface T. 1·51 C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
43	.	.	.	.	.	1	.	.	.	.	.	.	1	.	1
45	.	.	.	.	1	.	.	.	.	.	.	1	.	.	1
46	.	.	.	.	1	.	.	.	.	.	.	.	.	1	1
Total	.	.	.	.	2	1	.	.	.	.	.	1	1	1	3
Av. length	.	.	.	.	46	43	.	.	.	.	.	45	43	46	

MALES

Date January 17, 1931
St. No. 599
Net N 100 B 142–0 m.
Locality Bellingshausen Sea
Position {67° 08′ S, 69° 06½′ W
Surface T. −0·71° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
52	.	.	.	1	.	.	.	.	.	.	.	.	1	.	1
Total	.	.	.	1	.	.	.	.	.	.	.	.	1	.	1
Av. length	.	.	.	52	.	.	.	.	.	.	.	.	52	.	

FEMALES

Date January 17, 1931
St. No. 599
Net N 100 B 142–0 m.
Locality Bellingshausen Sea
Position {67° 08′ S, 69° 06½′ W
Surface T. −0·71° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
47	.	.	.	.	.	1	.	.	.	.	.	.	.	1	1
48	.	.	.	.	.	1	.	.	.	.	.	.	.	1	1
49	.	.	.	.	.	1	.	.	.	.	.	.	.	1	1
Total	.	.	.	.	.	3	.	.	.	.	.	.	.	3	3
Av. length	.	.	.	.	.	48	.	.	.	.	.	.	.	48	

Date January 19, 1931
St. No. 602
Net N 100 B} N 70 B } 110–0 m.
Locality Bellingshausen Sea
Position {66° 03½′ S, 66° 25′ W
Surface T. −0·02° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
41	.	.	.	1	.	.	.	.	.	.	1	.	.	.	1
42	.	.	.	1	.	.	.	.	.	.	1	.	.	.	1
45	.	.	.	1	.	.	1	.	.	.	.	1	.	1	2
46	.	.	.	1	.	.	.	.	.	.	1	.	.	.	1
47	.	.	.	.	.	.	2	.	.	.	.	.	.	2	2
48	.	.	.	.	2	.	1	.	.	.	.	.	2	1	3
49	.	.	.	2	1	.	2	.	.	.	2	.	1	2	5
50	.	.	.	1	1	1	2	.	.	.	1	.	2	2	5
51	.	.	.	.	.	.	5	.	.	.	.	.	.	5	5
52	.	.	.	.	.	.	2	.	.	.	.	.	.	2	2
53	.	.	.	1	1	.	1	.	.	.	.	.	2	1	3
54	.	.	.	.	.	1	2	.	.	.	.	.	1	2	3
Total	.	.	.	8	5	2	18	.	.	.	6	1	8	18	33
Av. length	.	.	.	47	50	52	50	.	.	.	46	45	51	50	

Date January 19, 1931
St. No. 602
Net N 100 B} N 70 B } 110–0 m.
Locality Bellingshausen Sea
Position {66° 03½′ S, 66° 25′ W
Surface T. −0·02° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
25	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
37	.	.	1	.	.	.	.	.	.	1	.	.	.	.	1
40	.	.	1	.	.	.	.	.	.	1	.	.	.	.	1
42	.	.	.	.	2	.	.	.	.	.	.	1	.	1	2
43	.	.	.	1	.	.	.	.	.	.	.	.	.	1	1
44	.	.	.	.	2	.	.	.	.	.	.	1	1	.	2
45	.	.	.	1	2	2	.	.	.	.	.	.	1	4	5
46	.	.	.	1	.	.	.	.	.	.	.	.	.	1	1
47	.	.	.	.	1	.	.	.	.	.	.	.	.	1	1
48	.	.	.	.	.	1	.	.	.	.	.	.	1	.	1
50	.	.	.	.	.	4	.	.	.	.	.	.	.	4	4
52	.	.	.	.	.	2	.	.	.	.	.	.	.	2	2
53	.	.	.	.	.	4	.	.	.	.	.	.	2	2	4
54	.	.	.	.	.	2	.	.	.	.	.	.	.	2	2
55	.	.	.	.	.	1	.	.	.	.	.	.	1	.	1
57	.	.	.	.	.	1	.	.	.	.	.	.	.	1	1
58	.	.	.	.	.	1	.	.	.	.	.	.	1	.	1
Total	1	.	2	3	7	18	.	1	.	2	.	2	7	19	31
Av. length	25	.	39	44	44	53	.	25	.	39	.	43	51	49	

Date January 20, 1931
St. No. 603
Net N 100 B 140–0 m.
Locality Bellingshausen Sea
Position {65° 04½′ S, 67° 51½′ W
Surface T. 1·08° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
47	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
50	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
53	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
55	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
Total	.	.	.	.	.	.	4	.	.	.	.	.	.	4	4
Av. length	.	.	.	.	.	.	51	.	.	.	.	.	.	51	

Date January 20, 1931
St. No. 603
Net N 100 B 140–0 m.
Locality Bellingshausen Sea
Position {65° 04½′ S, 67° 51½′ W
Surface T. 1·08° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
45	.	.	.	.	.	1	.	.	.	.	.	.	1	.	1
53	.	.	.	.	.	1	.	.	.	.	.	.	.	1	1
56	.	.	.	.	.	1	.	.	.	.	.	.	.	1	1
Total	.	.	.	.	.	3	.	.	.	.	.	.	1	2	3
Av. length	.	.	.	.	.	51	.	.	.	.	.	.	45	55	

Date January 25–26, 1931
St. No. WS 537
Net N 100 B 67–0 m.
Locality Approaching S. Sandwich Is.
Position {56° 10′ S, 25° 35′ W
Surface T. 0·57° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
18	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
19	2	.	.	.	.	.	.	2	.	.	.	.	.	.	2
20	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
21	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
22	3	.	.	.	.	.	.	3	.	.	.	.	.	.	3
23	2	.	.	.	.	.	.	2	.	.	.	.	.	.	2
24	2	.	.	.	.	.	.	2	.	.	.	.	.	.	2
25	3	.	.	.	.	.	.	3	.	.	.	.	.	.	3
26	2	.	.	.	.	.	.	2	.	.	.	.	.	.	2
27	7	1	.	.	.	.	.	8	.	.	.	.	.	.	8
28	4	1	.	.	.	.	.	4	1	.	.	.	.	.	5
29	3	2	.	.	.	.	.	4	1	.	.	.	.	.	5
30	2	4	.	.	.	.	.	6	.	.	.	.	.	.	6
31	.	3	.	.	.	.	.	1	2	.	.	.	.	.	3
32	.	3	.	.	.	.	.	.	3	.	.	.	.	.	3
33	.	4	.	.	.	.	.	2	2	.	.	.	.	.	4
34	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
35	.	1	1	.	.	.	.	.	2	.	.	.	.	.	2
40	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
43	.	.	1	.	.	.	.	.	.	1	.	.	.	.	1
49	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
50	.	.	.	.	.	.	3	.	.	.	.	.	.	3	3
Total	33	21	2	.	.	.	4	42	13	1	.	.	.	4	60
Av. length	25	35	39	.	.	.	50	25	33	43	.	.	.	50	

Date January 25–26, 1931
St. No. WS 537
Net N 100 B 67–0 m.
Locality Approaching S. Sandwich Is.
Position {56° 10′ S, 25° 35′ W
Surface T. 0·57° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
19	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
20	2	.	.	.	.	.	.	2	.	.	.	.	.	.	2
22	2	.	.	.	.	.	.	2	.	.	.	.	.	.	2
23	5	.	.	.	.	.	.	4	1	.	.	.	.	.	5
24	4	.	.	.	.	.	.	4	.	.	.	.	.	.	4
25	9	.	.	.	.	.	.	7	2	.	.	.	.	.	9
26	3	.	.	.	.	.	.	3	.	.	.	.	.	.	3
27	6	.	.	.	.	.	.	3	3	.	.	.	.	.	6
28	6	.	.	.	.	.	.	2	4	.	.	.	.	.	6
29	2	.	.	.	.	.	.	1	1	.	.	.	.	.	2
30	7	.	.	.	.	.	.	2	5	.	.	.	.	.	7
31	7	.	.	.	.	.	.	1	6	.	.	.	.	.	7
32	2	.	.	.	.	.	.	.	2	.	.	.	.	.	2
33	2	.	.	.	.	.	.	1	1		.	.	.	.	2
36	1	.	.	.	.	.	.	.	1	.	.	.	.	.	1
37	1	.	.	.	.	.	.	.	.	1	.	.	.	.	1
47	.	.	.	.	.	1	.	.	.	.	.	.	.	1	1
51	.	.	.	.	1	.	.	.	.	.	.	.	.	1	1
Total	60	.	.	.	1	1	.	33	26	1	.	.	.	2	62
Av. length	27	.	.	.	51	47	.	25	29	37	.	.	.	49	

MALES

Date February 22, 1928
St. No. WS 152
Net N 100 B 110–0 m.
Locality S. Georgia
Position 53° 12′ 00 S, 34° 52′ 00 W
Surface T. circa 1·30° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
34	.	.	1	.	.	.	.	.	.	1	.	.	.	.	1
41	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
43	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
44	.	.	.	.	.	.	2	.	.	.	.	.	.	2	2
45	.	.	1	.	.	.	2	.	.	.	.	1	.	2	3
46	.	.	1	.	.	.	7	.	.	.	.	1	.	7	8
47	.	.	.	.	.	.	4	.	.	.	.	.	.	4	4
48	.	.	.	.	.	.	4	.	.	.	.	.	.	4	4
49	.	.	.	.	.	.	6	.	.	.	.	.	.	6	6
50	.	.	.	.	.	.	14	.	.	.	.	.	.	14	14
51	.	.	.	.	.	.	9	.	.	.	.	.	.	9	9
52	.	.	.	.	.	.	6	.	.	.	.	.	.	6	6
53	.	.	.	.	.	.	5	.	.	.	.	.	.	5	5
54	.	.	1	.	.	.	1	.	.	.	.	1	.	1	2
55	.	.	.	.	.	.	3	.	.	.	.	.	.	3	3
57	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
Total	.	.	4	.	.	.	66	.	.	1	.	3	.	66	70
Av. length	.	.	45	.	.	.	50	.	.	34	.	46	.	50	

Date February 26, 1928
St. No. WS 156
Net N 70 V 100–50 m.
Locality S. Georgia
Position 53° 40′·00 S, 36° 52′·00 W
Surface T. circa 2·31° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
24	1	.	.	.	.	.	.	.	1	.	.	.	.	.	1
25	1	.	.	.	.	.	.	.	1	.	.	.	.	.	1
26	1	.	.	.	.	.	.	.	1	.	.	.	.	.	1
28	1	2	.	.	.	.	.	.	3	.	.	.	.	.	3
29	4	1	.	.	.	.	.	.	5	.	.	.	.	.	5
30	2	3	.	.	.	.	.	.	5	.	.	.	.	.	5
31	2	2	.	.	.	.	.	.	4	.	.	.	.	.	4
32	2	10	.	.	.	.	.	.	11	1	.	.	.	.	12
33	.	6	.	.	.	.	.	.	6	.	.	.	.	.	6
34	1	4	.	.	.	.	.	.	5	.	.	.	.	.	5
35	.	7	.	.	.	.	.	.	5	2	.	.	.	.	7
36	.	6	.	.	.	.	.	.	6	.	.	.	.	.	6
37	.	2	.	.	.	.	.	.	.	2	.	.	.	.	2
38	.	4	.	.	.	.	.	.	2	2	.	.	.	.	4
39	1	1	.	.	.	.	.	.	2	.	.	.	.	.	2
40	.	1	.	.	.	.	.	.	.	1	.	.	.	.	1
41	.	.	1	.	.	.	.	.	.	.	1	.	.	.	1
42	.	1	1	.	.	.	.	.	1	1	.	.	.	.	2
Total	16	50	2	.	.	.	.	.	58	9	1	.	.	.	68
Av. length	30	34	42	.	.	.	.	.	33	37	41	.	.	.	

Date February 8, 1929
St. No. WS 376
Net N 70 V 750–500 m.
Locality S. Orkney Is.
Position 57° 23′·00 S, 42° 52′·00 W
Surface T. 1·45° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
40	.	.	.	1	.	.	.	.	.	.	1	.	.	.	1
46	.	.	.	.	.	1	.	.	.	.	.	.	1	.	1
50	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
51	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
Total	.	.	.	1	.	1	2	.	.	.	1	.	1	2	4
Av. length	.	.	.	40	.	46	51	.	.	.	40	.	46	51	

Date February 1, 1930
St. No. 325
Net N 70 V 750–500 m.
Locality S. Georgia
Position 54° 53′ S, 39° 57′ W
Surface T. 3·32° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
41	.	.	1	.	.	.	.	.	1	.	.	.	.	.	1
Total	.	.	1	.	.	.	.	.	1	.	.	.	.	.	1
Av. length	.	.	41	.	.	.	.	.	41	.	.	.	.	.	

FEMALES

Date February 22, 1928
St. No. WS 152
Net N 100 B 110–0 m.
Locality S. Georgia
Position 53° 12′·00 S, 34° 52′·00 W
Surface T. circa 1·30° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
42	.	.	.	.	.	1	.	.	.	.	.	.	.	1	1
44	.	.	.	.	.	1	.	.	.	.	.	.	.	1	1
45	.	.	.	.	2	2	.	.	.	.	.	.	.	4	4
46	.	.	.	.	2	2	.	.	.	.	.	.	.	4	4
47	.	.	.	.	.	2	.	.	.	.	.	.	.	2	2
49	.	.	.	.	.	2	.	.	.	.	.	.	1	1	2
50	.	.	.	.	1	1	1	.	.	.	.	.	.	3	3
51	.	.	.	.	.	3	1	.	.	.	.	.	.	4	4
52	.	.	.	.	1	2	1	.	.	.	.	.	1	3	4
53	.	.	.	.	.	1	1	.	.	.	.	.	1	1	2
54	.	.	.	.	.	1	1	.	.	.	.	.	.	2	2
55	.	.	.	.	1	1	1	.	.	.	.	.	1	2	3
56	.	.	.	.	.	2	.	.	.	.	.	.	1	1	2
59	.	.	.	.	.	1	.	.	.	.	.	.	.	1	1
60	.	.	.	.	.	1	.	.	.	.	.	.	.	1	1
Total	.	.	.	.	7	23	6	.	.	.	.	.	5	31	36
Av. length	.	.	.	.	43	50	53	.	.	.	.	.	53	50	

Date February 26, 1928
St. No. WS 156
Net N 70 V 100–50 m.
Locality S. Georgia
Position 53° 40′ 00 S, 36° 52′ 00 W
Surface T. circa 2·31° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
25	2	.	.	.	.	.	.	2	.	.	.	.	.	.	2
26	2	.	.	.	.	.	.	2	.	.	.	.	.	.	2
27	1	.	.	.	.	.	.	.	1	.	.	.	.	.	1
28	3	.	.	.	.	.	.	1	2	.	.	.	.	.	3
29	5	.	.	.	.	.	.	.	5	.	.	.	.	.	5
30	1	1	.	.	.	.	.	1	1	.	.	.	.	.	2
31	6	1	.	.	.	.	.	1	6	.	.	.	.	.	7
32	3	2	.	.	.	.	.	.	5	.	.	.	.	.	5
33	1	3	.	.	.	.	.	.	4	.	.	.	.	.	4
34	2	6	.	.	.	.	.	.	8	.	.	.	.	.	8
35	2	2	.	.	.	.	.	1	3	.	.	.	.	.	4
36	.	2	.	.	.	.	.	.	1	1	.	.	.	.	2
37	1	2	.	.	.	.	.	.	3	.	.	.	.	.	3
38	.	1	1	.	.	.	.	.	.	2	.	.	.	.	2
Total	29	20	1	.	.	.	.	8	39	3	.	.	.	.	50
Av. length	30	34	38	.	.	.	.	28	32	37	.	.	.	.	

Date February 8, 1929
St. No. WS 376
Net N 70 V 750–500 m.
Locality S. Orkney Is.
Position 57° 23′·00 S, 42° 52′·00 W
Surface T. 1·45° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
50	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
53	.	.	.	.	.	1	.	.	.	.	.	.	.	1	1
Total	.	.	.	.	.	1	1	.	.	.	.	.	.	2	2
Av. length	.	.	.	.	.	53	50	.	.	.	.	.	.	52	

Date February 14, 1929
St. No. WS 381
Net N 70 V 50–0 m.
Locality S. Orkney Is.
Position 61° 26′ 00 S, 56° 19′ 00 W
Surface T. 1·65° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
48	.	1	.	.	.	.	.	.	.	1	.	.	.	.	1
Total	.	1	.	.	.	.	.	.	.	1	.	.	.	.	1
Av. length	.	48	.	.	.	.	.	.	.	48	.	.	.	.	

MALES

Date February 8, 1930
St. No. 349
Net N 100 B 60–0 m.
Locality S. Georgia
Position 55° 01′ S., 35° 27½′ W
Surface T. 3·00° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
33	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
37	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
40	.	2	1	.	.	.	.	.	3	.	.	.	.	.	3
41	.	1		.	.	.	.	.	1	.	.	.	.	.	1
42	.	2	2	.	.	.	.	.	.	3	1	.	.	.	4
43	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
44	.		1	.	.	.	.	.	.	1	.	.	.	.	1
45	.	.	1	.	.	.	.	.	.	.	1	.	.	.	1
49	.	.	1	.	.	.	.	.	.	.	1	.	.	.	1
Total	.	8	6	.	.	.	.	.	7	4	3	.	.	.	14
Av. length	.	40	44	.	.	.	.	.	39	43	45	.	.	.	

Date February 9, 1930
St. No. 351
Net N 100 B 48–0 m.
Locality S. Georgia
Position 54° 21½′ S., 35° 42′ W
Surface T. 3·78° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
42	.	.	2	.	.	.	.	.	2	.	.	.	.	.	2
43	.	.	2	1	.	.	.	.	1	2	.	.	.	.	3
44	.	.	2	.	.	.	.	.	1	1	.	.	.	.	2
45	.	.	4	.	.	.	.	.	.	2	2	.	.	.	4
46	.	.	3	.	1	.	.	.	.	2	1	1	.	.	4
47	.	.	1	2	.	.	.	.	.	1	2	.	.	.	3
48	.	.	1	2	.	.	.	.	.	.	2	1	.	.	3
49	.	.	1	.	.	.	.	.	.	.	1	.	.	.	1
50	.	.	3	1	.	.	1	.	.	2	1	1	.	1	5
52	.	.	1	.	.	.	.	.	.	.	1	.	.	.	1
53	.	.	2	.	.	.	.	.	.	1	1	.	.	.	2
54	.	.	.	1	1	.	.	.	.	.	.	1	1	.	2
55	.	.	.	.	.	1	.	.	.	.	.	.	1	.	1
56	.	.	.	.	1		.	.	.	.	.	.	.	1	1
57	.	.	.	1	1	.	.	.	.	.	.	1	1	.	2
58	.	.	.	1	.	.	.	.	.	.	.	.	1	.	1
59	.	.	.	1	2	.	.	.	.	.	.	2	1	.	3
60	.	.	.		1	.	.	.	.	.	.	.	1	.	1
64	.	.	.	.	.	1	.	.	.	.	.	.	1	.	1
Total	.	.	22	10	7	2	1	.	4	11	11	7	7	2	42
Av. length	.	.	47	51	56	60	50	.	43	46	48	53	58	53	

Date February 9, 1930
St. No. 352
Net N 100 B 58–0 m.
Locality S. Georgia
Position 54° 19′ S., 35° 24′ W
Surface T. 2·95° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
37	.	.	1	.	.	.	.	.	1	.	.	.	.	.	1
38	.	3	.	.	.	.	.	.	3	.	.	.	.	.	3
40	.	3	4	.	.	.	.	.	7	.	.	.	.	.	7
41	.	3	4	.	.	.	.	.	6	1	.	.	.	.	7
42	.	1	2	.	.	.	.	.	1	2	.	.	.	.	3
43	.	.	3	.	.	.	.	.	2	1	.	.	.	.	3
45	.	.	3	.	.	.	.	.	.	3	.	.	.	.	3
46	.	.	2	.	.	.	.	.	.	1	1	.	.	.	2
47	.	.	1	.	.	.	.	.	1	.	.	.	.	.	1
52	.	.	.	.	1	.	.	.	.	.	.	.	1	.	1
54	.	.	.	.	.	1	.	.	.	.	.	.	.	1	1
Total	.	10	20	.	1	1	.	.	21	8	1	.	1	1	32
Av. length	.	40	42	.	52	54	.	.	41	44	46	.	52	54	

FEMALES

Date February 8, 1930
St. No. 349
Net N 100 B 60–0 m.
N 70 V 50–0 m.
Locality S. Georgia
Position 55° 01′ S., 35° 27½′ W
Surface T. 3·00° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
36	4	.	.	.	.	.	.	.	.	4	.	.	.	.	4
37	4	.	.	.	1	.	.	.	2	2	1	.	.	.	5
38	1	.	.	.	.	.	.	.	.	1	.	.	.	.	1
39	3	.	.	.	.	.	.	.	.	3	.	.	.	.	3
40	2	.	.	.	1	.	.	.	.	2	.	.	.	1	3
41	1	.	.	.	.	.	.	.	.	1	.	.	.	.	1
42	3	.	.	.	.	.	.	.	.	3	.	.	.	.	3
46	1	.	.	.	.	.	.	.	.	1	.	.	.	.	1
Total	19	.	.	.	2	.	.	.	2	17	1	.	.	1	21
Av. length	39	.	.	.	39	.	.	.	37	39	37	.	.	40	

Date February 9, 1930
St. No. 351
Net N 100 B 48–0 m.
N 70 V 100–50 m.
Locality S. Georgia
Position 54° 21½′ S., 35° 42′ W
Surface T. 3·78° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
38	.	.	1	.	.	.	.	.	1	.	.	.	.	.	1
39	.	1	.	.	.	.	.	1	.	.	.	.	.	.	1
40	.	2	2	.	.	.	.	1	2	1	.	.	.	.	4
41	.	3	1	.	.	.	.	.	3	1	.	.	.	.	4
42	.	2	3	.	.	1	.	.	2	3	.	1	.	.	6
43	.	1	4	.	.	.	.	1	1	3	.	.	.	.	5
44	.	.	5	.	.	.	.	1	1	3	.	.	.	.	5
45	.	.	5	.	.	1	.	.	4	1	.	1	.	.	6
46	.	.	1	.	.	.	.	.	.	1	.	.	.	.	1
47	.	.	2	.	.		.	.	.	2	.	.	.	.	2
48	.	.	.	.	.	1	.	.	.	.	.	1	.	.	1
49	.	.	.	.	.	3	.	.	.	.	.	3	.	.	3
55	.	.	.	.	.	2	.	.	.	.	.	.	.	2	2
57	.	.	.	.	.	.	1*	.	.	.	.	.	.	1	1
58	.	.	.	.	.	.	5*	.	.	.	.	.	.	5	5
60	.	.	.	.	.	.	2*	.	.	.	.	.	.	2	2
Total	.	9	24	.	.	8	8	4	14	15	.	6	.	10	49
Av. length	.	41	43	.	.	49	58	42	42	44	.	47	.	58	

Date February 9, 1930
St. No. 352
Net N 100 B 58–0 m.
Locality S. Georgia
Position 54° 19′ S., 35° 24′ W
Surface T. 2·95° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
35	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
36	.	1	.	.	.	.	.	1	.	.	.	.	.	.	1
37	2	.	.	.	.	.	.	2	.	.	.	.	.	.	2
38	2	1	.	.	.	.	.	1	2	.	.	.	.	.	3
39	.	5	.	.	.	.	.	1	3	1	.	.	.	.	5
40	2	1	.	.	.	.	.	1	2	.	.	.	.	.	3
41	5	1	.	.	.	.	.	1	5	.	.	.	.	.	6
42	3	.	.	.	.	.	.	.	3	.	.	.	.	.	3
43	2	2	1	.	.	.	.	1	2	1	1	.	.	.	5
45	.	.	1	.	.	.	.	.	.	1	.	.	.	.	1
47	.	.	.	.	.	.	1*	.	.	.	.	.	.	1	1
55	.	.	.	.	.	.	1*	.	.	.	.	.	.	1	1
Total	17	11	2	.	.	.	2	9	17	3	1	.	.	2	32
Av. length	40	40	44	.	.	.	51	38	41	42	43	.	.	51	

MALES

Date February 9, 1930
St. No. 354
Net N 100 B 96–0 m.
Locality S. Georgia
Position 54° 15½′ S., 34° 47½′ W
Surface T. 2·35° C.

Length in mm.	1	2	3	4	5	6	7	A	B	C	D	E	F	G	Total in sample
35	.	1	.	.	.	.	.	.	1	.		.	.	.	1
38	.	1	.	.	.	.	.		1	.	.	.	.	.	1
39	.	2	.	.	.	.	.	.	2	.	.	.	.	.	2
40	.	.	1	.	.	.	.	.	1	.	.	.	.	.	1
41	.	2	1	.	.	.	.	.	2	1	.	.	.	.	3
42	.	8	10	.	.	.	.	.	4	14	.	.	.	.	18
43	.	1	4	.	.	.	.	.	1	3	1	.	.	.	5
44	.	.	2	.	.	.	.	.	.	2	.	.	.	.	2
45	.	.	9	.	.	.	.	.	1	6	2	.	.	.	9
46	.	.	1	.	.	.	.	.	.	.	1	.	.	.	1
47	.	.	4	.	.	.	.	.	.	2	2	.	.	.	4
48	.	.	1	.	.	.	.	.	.	.	1	.	.	.	1
49	.	.	3	.	.	.	1	.	.	2	1	.	.	1	4
50	.	.	.	.	.	.	2	.	.	.	.	.	1	1	2
51	.	.	2	.	.	.	5	.	.	.	2	.		5	7
52	.	.	.	.	.	3	7	.	.	.	1	2	1	6	10
53	.	.	.	.	.	.	6	.	.	.	.	.	3	3	6
54	.	.	.	.	.	2	7	.	.	.	2	.	2	5	9
55	.	.	.	.	.	2	14	.	.	.	1	1	4	10	16
56	.	.	.	1	.	1	5	.	.	.	2	.	4	1	7
57	.	.	.	.	.	.	6	.	.	.	1	.	3	2	6
58	.	.	.	.	.	2	5	.	.	.	1	.	2	4	7
59	.	.	.	.	.	1	1	.	.	.	1	.		1	2
60	.	.	.	.	.	.	2	.	.	.	.	.	.	2	2
Total	.	15	38	1	.	11	61	.	13	30	19	3	20	41	126
Av. length	.	41	45	56	.	55	55	.	41	44	51	53	55	54	

FEMALES

Date February 9, 1930
St. No. 354
Net N 100 B 96–0 m.
Locality S. Georgia
Position 54° 15½′ S., 34° 47½′ W
Surface T. 2·35° C.

Length in mm.	1	2	3	4	5	6	7	A	B	C	D	E	F	G	Total in sample
34	.	1	.					1					.	.	1
36	.	2	.			.	.	1	1	.				.	2
37		2						2		.	.			.	2
38		1	.	.	.		.	.	1					.	1
39		1	1				.	1	1	.	.			.	2
40		3	.				.	.	2	1				.	3
41	.	3	1					1	3						4
42		.	.			2		.			2				2
43		.	2			1		.	2		1				3
44		2	.	.		.				2				.	2
45	.	3	.		.	.	.		1		2		.	.	3
46	.	.	1	.	.	1		.		1	1		.	.	2
47	.	.	1	.	.	.	.			1	.	.	.	.	1
49	.		1	.	.	.			.	1		.	.	.	1
50		.	.	.	.		1*		.				1		1
51	.	.	.	.	.		3*		.				1	2	3
52		.	.	.		.	3*	.	.				.	3	3
53	.		.	.	.	1	1 8*	.						10	10
54	.	.	.	.	.	1	6*	.					2	5	7
55	.	.	.	.	.		4*	.					1	3	4
56	.	.	.	.			3*	.	.					3	3
57	.	.				.	5*					.	1	4	5
59	.	.				1	1*	.						2	2
Total	.	18	7		.	7	35	6	11	6	6		6	32	67
Av. length	.	40	44	.	.	48	53	37	41	45	44		54	55	

Date February 10, 1930
St. No. 356
Net N 70 V 250–100 m.
Locality S. Georgia
Position 54° 11′ S., 33° 49′ W
Surface T. 2·02° C.

Length in mm.	1	2	3	4	5	6	7	A	B	C	D	E	F	G	Total in sample
40	.	.	1	.	.	.	.	.	1	.	.	.	.	.	1
41	.	.	2	.	.	.	.	.	2	.	.	.	.	.	2
43	.	.	1	.	.	.	.	.	.	.	1	.	.	.	1
44	.	.	2	.	.	.	.	.	.	2	.	.	.	.	2
45	.	.	3	.	.	.	.	.	.	3	.	.	.	.	3
46	.	.	4	.	.	.	.	.	1	2	1	.	.	.	4
48	.	.	6	1	.	.	.	.	2	3	1	1	.	.	7
50	.	.	1	1	.	.	.	.	.	1		1	.	.	2
51	.	.	.	1	.	.	.	.	.	.	.	1	.	.	1
54	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
56	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
57	.	.	.	.	.	1	.	.	.	.	.	.	.	1	1
59	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
Total	.	.	20	3	.	1	3	.	6	11	3	3	.	4	27
Av. length	.	.	46	50	.	57	56	.	44	46	46	50	.	57	

Date February 10, 1930
St. No. 356
Net N 70 V 250–100 m.
Locality S. Georgia
Position 54° 11′ S., 33° 49′ W
Surface T. 2·02° C.

Length in mm.	1	2	3	4	5	6	7	A	B	C	D	E	F	G	Total in sample
38	.	.	1	.	.	.			.	1	.		.	.	1
39	.	.	1		.			.	1				.	.	1
42	.	.	1	.	.	1	.	.		1	1	.	.	.	2
49	.	.	.	.	.	1	.	.			1	.	.	.	1
50	.	.	.	.	.	.	1	.						1	1
52	.	.	.	.	.	.	2	.	.		.	.	1	1	2
53	.	.	.	.	.	.	2	.	.		.		.	2	2
54	.	.	.	.	.	.	1*	.	.					1	1
55	.	.	.	.	.	.	6							6	6
56	.	.	.	.	.	.	1		.			.		1	1
57	.	.	.	.	.	.	3		.					3	3
58	.	.	.	.	.	1	5							6	6
59	.	.	.	.	.	.	3 1*	.	.	.	.		1	3	4
60	.	.	.	.	.	.	10	.					1	9	10
61	.	.	.	.	.	.	4 1*	.	.	.	.	.	.	5	5
63	.	.	.	.	.	.	1	.			.	.	.	1	1
64	.	.	.	.	.	.	1	.	.		.	.	.	1	1
Total	.	.	3	.	.	3	42	.	1	2	2	.	3	40	48
Av. length	.	.	40		.	50	58	.	39	39	45	.	57	58	

Date February 8, 1931
St. No. 609
Net N 100 B 128–0 m.
Locality Bransfield Strait
Position 62° 08¼′ S., 62° 57¼′ W
Surface T. 2·03° C.

Length in mm.	1	2	3	4	5	6	7	A	B	C	D	E	F	G	Total in sample
47	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
48	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
52	.	.	.	.	.	.	3	.	.	.	.	.	.	3	3
53	.	.	.	.	.	.	3	.	.	.	.	.	.	3	3
Total	.	.	.	.	.	.	8	.	.	.	.	.	.	8	8
Av. length	.	.	.	.	.	.	51	.	.	.	.	.	.	51	

Date February 8, 1931
St. No. 609
Net N 100 B 128–0 m.
Locality Bransfield Strait
Position 62° 08¼′ S., 62° 57¼′ W
Surface T 2·03° C.

Length in mm.	1	2	3	4	5	6	7	A	B	C	D	E	F	G	Total in sample
49	.	.	.	-	.	1	.	.	.	.		.	1	.	1
51	.	.	.	.	.	1		.	.	.	.	.	.	1	1
55	.	.	.	.	.	1	.	.	.	.	.	.	1	.	1
Total	.	.	.	.	.	3	.	.	.	.	.	.	2	1	3
Av. length	.	.	.	.	.	52	.	.			.	.	52	51	

MALES

Date February 10, 1931
St. No. 612
Net N 100 B 160–0 m.
N 50 V 100–0 m.
Locality Bransfield Strait
Position 62° 42′ S, 57° 10′ W
Surface T. 0·52° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
20	1	.	.	.	.	.	.	.	1	.	.	.	.	.	1
21	2	.	.	.	.	.	.	.	2	.	.	.	.	.	2
22	1	.	.	.	.	.	.	.	1	.	.	.	.	.	1
23	6	.	.	.	.	.	.	.	6	.	.	.	.	.	6
24	3	4	.	.	.	.	.	.	7	.	.	.	.	.	7
25	11	5	.	.	.	.	.	1	15	.	.	.	.	.	16
26	9	20	.	.	.	.	.	.	29	.	.	.	.	.	29
27	10	21	.	.	.	.	.	.	31	.	.	.	.	.	31
28	3	13	.	.	.	.	.	.	16	.	.	.	.	.	16
29	1	10	2	.	.	.	.	.	13	.	.	.	.	.	13
30	1	32	3	.	.	.	.	1	35	.	.	.	.	.	36
31	1	13	1	.	.	.	.	1	14	.	.	.	.	.	15
32	.	12	2	.	.	.	.	.	14	.	.	.	.	.	14
33	.	6	1	.	.	.	.	.	7	.	.	.	.	.	7
34	.	2	3	.	.	.	.	.	4	1	.	.	.	.	5
35	.	1	7	.	.	.	.	.	6	2	.	.	.	.	8
36	.	1	2	.	.	.	.	.	1	2	.	.	.	.	3
37	.	.	4	1	.	.	.	.	2	3	.	.	.	.	5
38	.	3	5	.	.	.	.	.	6	2	.	.	.	.	8
39	.	1	3	.	.	.	.	.	2	1	1	.	.	.	4
40	.	1	3	1	.	.	.	.	.	1	3	1	.	.	5
41	.	.	1	3	.	.	.	.	.	.	4	.	.	.	4
42	.	1	3	.	.	.	.	.	.	4	.	.	.	.	4
43	.	.	3	.	1	.	.	.	.	.	3	.	1	.	4
44	.	.	1	2	.	.	.	.	.	.	3	.	.	.	3
45	.	.	8	2	1	.	.	.	.	.	1	10	.	.	11
46	.	.	.	2	.	.	.	.	.	.	1	1	.	.	2
47	.	.	9	7	.	1	.	.	.	.	6	9	2	.	17
48	.	.	2	3	.	.	.	.	.	.	2	2	1	.	5
49	.	.	6	3	.	.	.	.	.	.	2	7	.	.	9
50	.	.	4	4	.	.	.	.	.	.	.	7	1	.	8
51	.	.	2	2	1	1	.	.	.	.	.	3	2	1	6
52	.	.	.	3	1	.	.	.	.	.	.	3	1	.	4
53	.	.	1	4	.	.	.	.	.	.	1	3	1	.	5
54	.	.	1	2	.	.	.	.	.	.	.	1	2	.	3
Total	49	146	77	39	4	2	.	3	212	16	27	47	11	1	317
Av. length	25	29	41	48	48	49	.	29	29	38	45	48	50	51	

FEMALES

Date February 10, 1931
St. No. 612
Net N 100 B 160–0 m.
Locality Bransfield Strait
Position 62° 42′ S, 57° 10′ W
Surface T. 0·52° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
16	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
19	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
21	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
22	3	.	.	.	.	.	.	3	.	.	.	.	.	.	3
23	5	.	.	.	.	.	.	5	.	.	.	.	.	.	5
24	20	.	.	.	.	.	.	20	.	.	.	.	.	.	20
25	41	.	.	.	.	.	.	41	.	.	.	.	.	.	41
26	31	.	.	.	.	.	.	.	31	.	.	.	.	.	31
27	.	34	.	.	.	.	.	34	.	.	.	.	.	.	34
28	.	18	.	.	.	.	.	18	.	.	.	.	.	.	18
29	.	19	.	.	.	.	.	19	.	.	.	.	.	.	19
30	.	42	.	.	.	.	.	42	.	.	.	.	.	.	42
31	.	.	12	.	.	.	.	.	12	.	.	.	.	.	12
32	.	.	24	.	.	.	.	.	24	.	.	.	.	.	24
33	.	.	15	.	.	.	.	.	15	.	.	.	.	.	15
34	.	.	6	.	.	.	.	.	6	.	.	.	.	.	6
35	.	.	20	.	.	.	.	.	19	.	1	.	.	.	20
36	.	.	6	.	.	.	.	.	6	.	.	.	.	.	6
37	.	.	3	.	.	.	.	.	3	.	.	.	.	.	3
40	.	.	.	.	.	.	2*	.	.	.	.	.	.	2	2
41	.	.	.	.	.	.	1*	.	.	.	.	.	.	1	1
42	.	.	.	.	.	.	1*	.	.	.	.	.	.	1	1
43	.	.	.	.	.	.	3*	.	.	.	.	.	.	3	3
44	.	.	.	.	.	.	7*	.	.	.	.	.	.	7	7
45	.	.	.	.	.	.	14*	.	.	.	.	.	1	13	14
46	.	.	.	.	.	.	7*	.	.	.	.	.	.	7	7
47	.	.	.	.	.	.	4*	.	.	.	.	.	.	4	4
48	.	.	.	.	.	.	6*	.	.	.	.	.	.	6	6
49	.	.	.	.	.	.	5*	.	.	.	.	.	.	5	5
50	.	.	.	.	.	.	6*	.	.	.	.	.	.	6	6
51	.	.	.	.	.	.	1*	.	.	.	.	.	.	1	1
53	.	.	.	.	.	.	1*	.	.	.	.	.	.	1	1
Total	103	113	86	.	.	.	58	185	116	.	1	.	1	57	360
Av. length	24	29	33	.	.	.	47	27	31	.	35	.	45	47	

Date February 12, 1931
St No. 613
Net N 100 B 182–0 m.
Locality S. Orkney Is.
Position 60° 59¾′ S, 50° 42½′ W
Surface T. −0·21° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
45	.	.	.	.	.	1	.	.	.	.	.	.	1	.	1
Total	.	.	.	.	.	1	.	.	.	.	.	.	1	.	1
Av. length	.	.	.	.	.	45	.	.	.	.	.	.	45	.	

Date February 12, 1931
St. No. 613
Net N 100 B 182–0 m.
Locality S. Orkney Is.
Position 60° 59¾′ S, 50° 42½′ W
Surface T. −0·21° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
22	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
23	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
26	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
35	.	1	.	.	.	.	.	.	.	1	.	.	.	.	1
42	.	.	.	.	.	.	1*	.	.	.	.	.	.	1	1
Total	3	1	.	.	.	.	1	3	.	1	.	.	.	1	5
Av. length	24	35	.	.	.	.	42	24	.	35	.	.	.	42	

Date February 18–19, 1931
St. No. 618
Net N 100 B 119–0 m.,
N 70 V 50–0 m.
Locality S. Orkney Is.
Position 59° 42¾′ S, 43° 57¾′ W
Surface T. 1·29° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
27	2	.	.	.	.	.	.	2	.	.	.	.	.	.	2
30	2	1	.	.	.	.	.	.	3	.	.	.	.	.	3
32	4	2	.	.	.	.	.	4	2	.	.	.	.	.	6
33	1	5	.	.	.	.	.	1	5	.	.	.	.	.	6
34	.	9	.	.	.	.	.	.	9	.	.	.	.	.	9
35	.	4	.	.	.	.	.	.	4	.	.	.	.	.	4
36	.	3	.	.	.	.	.	.	3	.	.	.	.	.	3
37	.	4	.	.	.	.	.	.	4	.	.	.	.	.	4
38	.	3	.	.	.	.	.	.	3	.	.	.	.	.	3
39	.	2	.	.	.	.	.	.	2	.	.	.	.	.	2
40	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
41	.	2	.	.	.	.	.	.	2	.	.	.	.	.	2
45	.	.	1	.	.	.	.	.	.	1	.	.	.	.	1
51	.	.	.	.	.	1	.	.	.	.	.	.	.	1	1
54	.	.	.	.	.	1	.	.	.	.	.	.	.	1	1
Total	9	36	1	.	.	2	.	7	38	1	.	.	.	2	48
Av. length	31	35	45	.	.	53	.	31	35	45	.	.	.	53	

Date February 18–19, 1931
St. No 618
Net N 100 B 119–0 m.,
N 70 V 50–0 m.
Locality S. Orkney Is.
Position 59° 42¾′ S, 43° 57¾′ W
Surface T. 1·29° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
26	2	.	.	.	.	.	.	2	.	.	.	.	.	.	2
27	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
28	1	.	.	.	.	.	.	.	1	.	.	.	.	.	1
29	3	.	.	.	.	.	.	1	2	.	.	.	.	.	3
30	4	3	.	.	.	.	.	1	6	.	.	.	.	.	7
31	1	1	.	.	.	.	.	.	2	.	.	.	.	.	2
32	.	3	.	.	.	.	.	.	3	.	.	.	.	.	3
33	2	4	.	.	.	.	.	2	4	.	.	.	.	.	6
34	.	2	.	.	.	.	.	.	2	.	.	.	.	.	2
35	1	11	.	.	.	.	.	.	11	1	.	.	.	.	12
36	.	3	1	.	.	.	.	.	4	.	.	.	.	.	4
37	.	5	.	.	.	.	.	.	5	.	.	.	.	.	5
38	.	4	.	.	.	.	.	.	2	2	.	.	.	.	4
40	.	1	.	.	.	.	.	.	.	1	.	.	.	.	1
45	.	.	.	.	.	.	3*	.	.	.	.	.	.	3	3
50	.	.	.	.	.	.	1*	.	.	.	.	.	.	1	1
51	.	.	.	.	.	.	2*	.	.	.	.	.	.	2	2
52	.	.	.	.	.	.	1*	.	.	.	.	.	.	1	1
54	.	.	.	.	.	.	4*	.	.	.	.	.	.	4	4
Total	15	37	1	.	.	.	11	7	42	4	.	.	.	11	64
Av. length	29	35	36	.	.	.	50	29	34	38	.	.	.	50	

MALES

Date February 20, 1931
St. No. 621
Net N 100 B 100–0 m.
Locality S. Orkney Is.
Position 58° 50¼′ S., 38° 53′ W
Surface T. 0·25° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
39	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
42	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
Total	.	2	.	.	.	.	.	.	2	.	.	.	.	.	2
Av. length	.	41	.	.	.	.	.	.	41	.	.	.	.	.	

Date February 20, 1931
St. No. 622
Net N 100 B 155–0 m., N 70 V 50–0 m., N 50 V 100–0 m.
Locality S. Sandwich Is.
Position 59° 05½′ S., 36° 25′ W
Surface T. −0·89° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
25	1	.	.	.	.	.	.	.	1	.	.	.	.	.	1
26	2	.	.	.	.	.	.	2	.	.	.	.	.	.	2
27	2	.	.	.	.	.	.	1	1	.	.	.	.	.	2
30	7	.	.	.	.	.	.	.	7	.	.	.	.	.	7
32	2	.	.	.	.	.	.	.	2	.	.	.	.	.	2
33	2	1	.	.	.	.	.	.	3	.	.	.	.	.	3
34	3	2	.	.	.	.	.	.	5	.	.	.	.	.	5
35	2	8	.	.	.	.	.	.	10	.	.	.	.	.	10
36	7	2	.	.	.	.	.	.	9	.	.	.	.	.	9
37	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
38	1	5	.	.	.	.	.	.	6	.	.	.	.	.	6
39	.	2	2	.	.	.	.	.	2	2	.	.	.	.	4
40	.	2	.	.	.	.	.	.	2	.	.	.	.	.	2
41	.	.	1	.	.	.	.	.	.	1	.	.	.	.	1
42	.	.	2	.	.	.	.	.	2	.	.	.	.	.	2
43	.	1	1	.	.	.	.	.	.	2	.	.	.	.	2
49	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
Total	29	24	6	.	.	.	1	3	51	5	.	.	.	1	60
Av. length	32	37	41	.	.	.	49	26	35	41	.	.	.	49	

Date February 21–22, 1931
St. No. 624
Net N 100 B 137–0 m., N 70 V 50–0 m.
Locality S. Sandwich Is.
Position 58° 34¾′ S., 31° 21½′ W
Surface T. 0·22° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
21	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
22	3	.	.	.	.	.	.	3	.	.	.	.	.	.	3
23	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
24	2	.	.	.	.	.	.	1	1	.	.	.	.	.	2
25	8	.	.	.	.	.	.	6	2	.	.	.	.	.	8
26	5	.	.	.	.	.	.	3	2	.	.	.	.	.	5
27	4	.	.	.	.	.	.	1	3	.	.	.	.	.	4
28	3	.	.	.	.	.	.	.	3	.	.	.	.	.	3
29	1	.	.	.	.	.	.	.	1	.	.	.	.	.	1
30	8	.	.	.	.	.	.	.	8	.	.	.	.	.	8
31	2	.	.	.	.	.	.	.	2	.	.	.	.	.	2
32	1	1	.	.	.	.	.	.	2	.	.	.	.	.	2
35	2	.	1	.	.	.	.	.	2	1	.	.	.	.	3
36	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
37	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
41	.	.	1	.	.	.	.	.	.	1	.	.	.	.	1
Total	41	3	2	.	.	.	.	16	28	2	.	.	.	.	46
Av. length	27	35	38	.	.	.	.	24	30	38	.	.	.	.	

Date February 22, 1931
St. No. 626
Net N 100 B 158–0 m.
Locality S. Sandwich Is.
Position 57° 22′ S., 26° 29¼′ W
Surface T. −0·09° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
19	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
20	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
21	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
23	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
24	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
25	1	.	.	.	.	.	.	.	1	.	.	.	.	.	1
29	3	.	.	.	.	.	.	.	3	.	.	.	.	.	3
Total	9	.	.	.	.	.	.	5	4	.	.	.	.	.	9
Av. length	24	.	.	.	.	.	.	21	28	.	.	.	.	.	

FEMALES

Date February 20, 1931
St. No. 621
Net N 100 B 100–0 m.
Locality S. Orkney Is.
Position 58° 50¼′ S., 38° 53′ W
Surface T. 0·25° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
28	1	.	.		.	.		.	1	.	.	.	.		1
Total	1	.	.	.	.	.	.	.	1			.	.	.	1
Av. length	28	.	.	.	.	.	.	.	28	.			.	.	

Date February 20, 1931
St. No. 622
Net N 100 B 155–0 m.
Locality S. Sandwich Is.
Position 59° 05½′ S., 36° 25′ W
Surface T. 0·89° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
23	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
25	4	.	.	.	.	.	.	3	1	.	.	.	.	.	4
27	1	1	.	.	.	.	.	1	1	.	.	.	.	.	2
28	4	.	.	.	.	.	.	1	3	.	.	.	.	.	4
29	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
30	2	3	.	.	.	.	.	1	4	.	.	.	.	.	5
31	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
32	.	3	.	.	.	.	.	.	3	.	.	.	.	.	3
33	.	2	.	.	.	.	.	.	2	.	.	.	.	.	2
34	1	3	.	.	.	.	.	.	3	1	.	.	.	.	4
35	.	9	.	.	.	.	.	.	3	6	.	.	.	.	9
36	.	2	.	.	.	.	.	.	2	.	.	.	.	.	2
38	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
39	.	1	.	.	.	.	.	.	.	1	.	.	.	.	1
40	.	1	.	.	.	.	.	.	.	1	.	.	.	.	1
41	.	1	.	.	.	.	.	.	.	1	.	.	.	.	1
50	.	.	.	.	.	.	1*	.	.	.	.	.	.	1	1
56	.	.	.	.	.	.	1*		.	.	.	.	.	1	1
Total	13	29	.	.	.	.	2	7	25	10	.	.	.	2	44
Av. length	27	34	.	.	.	.	53	26	32	36	.	.	.	53	

Date February 21–22, 1931
St. No. 624
Net N 100 B 137–0 m.
Locality S. Sandwich Is.
Position 58° 34¾′ S., 31° 21½′ W
Surface T. 0·22° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
21	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
23	2	.	.	.	.	.	.	1	1	.	.	.	.	.	2
24	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
25	1	1	.	.	.	.	.	1	1	.	.	.	.	.	2
27	4	2	.	.	.	.	.	4	2	.	.	.	.	.	6
29	.	2	.	.	.	.	.	.	2	.	.	.	.	.	2
30	1	4	.	.	.	.	.	1	4	.	.	.	.	.	5
31	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
32	1	2	.	.	.	.	.	1	2	.	.	.	.	.	3
35	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
36	.	1	.	.	.	.	.	.	.	1	.	.	.	.	1
48	.	.	.	.	1	.	.	.	.	.	.	.	.	1	1
Total	10	15	.	.	1	.	.	9	15	1	.	.	.	1	26
Av. length	27	30	.	.	48	.	.	27	29	36	.	.	.	48	

Date February 22, 1931
St. No. 626
Net N 100 B 158–0 m.
Locality S. Sandwich Is.
Position 57° 22′ S., 26° 29¼′ W
Surface T. −0·09° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
18	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
19	2	.	.	.	.	.	.	2	.	.	.	.	.	.	2
20	3	.	.	.	.	.	.	3	.	.	.	.	.	.	3
22	6	.	.	.	.	.	.	6	.	.	.	.	.	.	6
23	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
24	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
26	1	.	.	.	.	.	.	.	1	.	.	.	.	.	1
28	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
30	.	2	.	.	.	.	.	.	2	.	.	.	.	.	2
32	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
Total	15	4	.	.	.	.	.	14	5	.	.	.	.	.	19
Av. length	21	30	.	.	.	.	.	21	29	.	.	.	.		

MALES

Date	February 23, 1931	Locality	S. Sandwich Is.
St. No.	627	Position	56° 53¾′ S. 23° 47½′ W
Net	N 100 B 118–0 m.	Surface T.	1·10° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
23	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
24	2	.	.	.	.	.	.	2	.	.	.	.	.	.	2
25	3	.	.	.	.	.	.	3	.	.	.	.	.	.	3
26	4	.	.	.	.	.	.	4	.	.	.	.	.	.	4
27	8	.	.	.	.	.	.	7	1	.	.	.	.	.	8
28	2	.	.	.	.	.	.	.	2	.	.	.	.	.	2
29	7	.	.	.	.	.	.	6	1	.	.	.	.	.	7
30	2	3	.	.	.	.	.	.	5	.	.	.	.	.	5
31	1	2	.	.	.	.	.	.	3	.	.	.	.	.	3
32	.	2	.	.	.	.	.	.	2	.	.	.	.	.	2
33	.	2	.	.	.	.	.	.	2	.	.	.	.	.	2
34	1	2	.	.	.	.	.	.	3	.	.	.	.	.	3
35	.	2	.	.	.	.	.	.	.	2	.	.	.	.	2
36	.	4	.	.	.	.	.	.	4	.	.	.	.	.	4
37	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
38	.	.	3	.	.	.	.	.	2	1	.	.	.	.	3
40	.	.	1	.	.	.	.	.	.	1	.	.	.	.	1
45	.	.	1	.	.	.	.	.	.	.	.	1	.	.	1
51	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
Total	31	18	5	.	.	.	1	23	26	4	.	1	.	1	55
Av. length	27	33	40	.	.	.	51	27	33	37	.	45	.	51	

Date	February 24, 1931	Locality	S. Sandwich Is.
St. No.	628	Position	55° 52¼′ S. 26° 44′ W
Net	N 100 B 126–0 m.	Surface T.	−0·15° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
32	1	.	.	.	.	.	.	.	1	.	.	.	.	.	1
Total	1	.	.	.	.	.	.	.	1	.	.	.	.	.	1
Av. length	32	.	.	.	.	.	.	.	32	.	.	.	.	.	

Date	February 25, 1931	Locality	S. Sandwich Is. —S. Georgia
St. No.	629	Position	55° 33¾′ S. 30° 01′ W
Net	N 100 B 152–0 m.	Surface T.	0·11° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
20	2	.	.	.	.	.	.	2	.	.	.	.	.	.	2
23	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
29	1	.	.	.	.	.	.	.	1	.	.	.	.	.	1
32	1	1	.	.	.	.	.	.	2	.	.	.	.	.	2
34	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
36	.	2	.	.	.	.	.	.	2	.	.	.	.	.	2
Total	5	4	.	.	.	.	.	3	6	.	.	.	.	.	9
Av. length	25	35	.	.	.	.	.	21	33	.	.	.	.	.	

FEMALES

Date	February 23, 1931	Locality	S. Sandwich Is.
St. No.	627	Position	56° 53¾′ S. 23° 47½′ W
Net	N 100 B 118–0 m.	Surface T.	1·10° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
21	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
25	1	6	.	.	.	.	.	3	4	.	.	.	.	.	7
26	.	6	.	.	.	.	.	3	3	.	.	.	.	.	6
27	.	4	.	.	.	.	.	1	3	.	.	.	.	.	4
28	.	3	.	.	.	.	.	1	2	.	.	.	.	.	3
29	.	2	.	.	.	.	.	1	1	.	.	.	.	.	2
30	.	10	.	.	.	.	.	2	8	.	.	.	.	.	10
31	.	2	.	.	.	.	.	.	2	.	.	.	.	.	2
32	.	3	.	.	.	.	.	1	2	.	.	.	.	.	3
33	.	2	.	.	.	.	.	.	2	.	.	.	.	.	2
34	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
35	.	2	.	.	.	.	.	.	2	.	.	.	.	.	2
36	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
38	.	2	.	.	.	.	.	.	1	1	.	.	.	.	2
Total	2	44	.	.	.	.	.	13	32	1	.	.	.	.	46
Av. length	23	29	.	.	.	.	.	27	30	38	.	.	.	.	

Date	February 24, 1931	Locality	S. Sandwich Is.
St. No.	628	Position	55° 52¼′ S. 26° 44′ W
Net	N 100 B 126–0 m.	Surface T.	−0·15° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
26	1	.	.	.	.	.	.	.	1	.	.	.	.	.	1
30	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
Total	1	1	.	.	.	.	.	.	2	.	.	.	.	.	2
Av. length	26	30	.	.	.	.	.	.	28	.	.	.	.	.	

Date	February 25, 1931	Locality	S. Sandwich Is. —S. Georgia
St. No.	629	Position	55° 33¾′ S. 30° 01′ W
Net	N 100 B 152–0 m.	Surface T.	0·11° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
25	2	.	.	.	.	.	.	2	.	.	.	.	.	.	2
30	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
Total	2	1	.	.	.	.	.	2	1	.	.	.	.	.	3
Av. length	25	30	.	.	.	.	.	25	30	.	.	.	.	.	

MALES

Date	March 14, 1926	Locality	S. Georgia
St. No.	23	Position	Cumberland Bay
Net	N 100 H 60–(0) m.	Surface T.	2·67° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
26	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
37	.	.	1	.	.	.	.	.	.	1	.	.	.	.	1
38	.	.	1	.	.	.	.	.	.	1	.	.	.	.	1
40	.	.	5	.	.	.	.	.	.	2	3	.	.	.	5
41	.	.	1	.	.	.	.	.	.	1	.	.	.	.	1
42	.	.	4	.	.	.	.	.	.	2	2	.	.	.	4
43	.	.	1	2	.	.	.	.	.	.	3	.	.	.	3
44	.	.	6	3	.	.	.	.	.	1	8	.	.	.	9
45	.	.	3	2	.	.	.	.	.	1	4	.	.	.	5
46	.	.	4	2	.	.	.	.	.	.	6	.	.	.	6
47	.	.	2	.	.	.	.	.	.	.	2	.	.	.	2
48	.	.	2	2	.	.	.	.	.	.	3	1	.	.	4
49	.	.	.	1	.	.	.	.	.	.	.	1	.	.	1
Total	1	.	30	12	.	.	.	1	.	9	31	2	.	.	43
Av. length	26	.	43	45	.	.	.	26	.	41	44	49	.	.	

Date	March 14, 1926	Locality	S. Georgia
St. No.	24	Position	Cumberland Bay
Net	N 100 H 60–(0) m.	Surface T.	circa 2·67° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
40	.	.	1	.	.	.	.	.	1	.	.	.	.	.	1
42	.	.	1	.	.	.	.	.	.	1	.	.	.	.	1
45	.	.	1	1	.	.	.	.	.	1	1	.	.	.	2
46	.	.	1	.	.	.	.	.	.	.	1	.	.	.	1
Total	.	.	4	1	.	.	.	.	1	2	2	.	.	.	5
Av. length	.	.	43	45	.	.	.	.	40	44	46	.	.	.	

Date	March 19, 1926	Locality	S. Georgia
St. No.	38	Position	Cumberland Bay
Net	N 100 H 50–(0) m.	Surface T.	circa 2·85° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
36	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
37	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
38	.	.	1	.	.	.	.	.	.	1	.	.	.	.	1
39	.	3	.	.	.	.	.	.	3	.	.	.	.	.	3
40	.	1	2	.	.	.	.	.	.	3	.	.	.	.	3
41	.	1	4	.	.	.	.	.	1	3	1	.	.	.	5
42	.	.	2	.	.	.	.	.	1	1	.	.	.	.	2
43	.	.	3	1	.	.	.	.	.	3	1	.	.	.	4
44	.	.	4	.	.	.	.	.	.	2	2	.	.	.	4
45	.	.	8	1	.	.	.	.	.	4	5	.	.	.	9
46	.	.	3	.	.	.	.	.	.	2	1	.	.	.	3
47	.	.	4	1	.	.	.	.	.	1	4	.	.	.	5
48	.	.	4	.	.	.	.	.	.	1	3	.	.	.	4
49	.	.	1	2	.	.	.	.	.	.	2	1	.	.	3
50	.	.	.	1	.	.	.	.	.	.	1	.	.	.	1
Total	.	7	36	6	.	.	.	.	7	21	20	1	.	.	49
Av. length	.	39	44	47	.	.	.	.	39	43	46	49	.	.	

FEMALES

Date	March 14, 1926	Locality	S. Georgia
St. No.	23	Position	Cumberland Bay
Net	N 100 H 60–(0) m.	Surface T.	2·67° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
35	3	.	.	.	.	.	.	.	1	2	.	.	.	.	3
36	3	.	.	.	.	.	.	.	2	1	.	.	.	.	3
37	2	.	.	.	.	.	.	.	1	1	.	.	.	.	2
38	2	2	.	.	.	.	.	.	.	2	2	.	.	.	4
39	3	.	.	.	.	.	.	.	1	2	.	.	.	.	3
40	3	.	.	.	.	.	.	.	.	3	.	.	.	.	3
41	4	.	.	.	.	.	.	.	.	3	1	.	.	.	4
42	4	.	.	.	.	.	.	.	1	3	.	.	.	.	4
43	3	3	.	.	.	.	.	.	.	3	2	1	.	.	6
44	.	1	.	.	.	.	.	.	.	1	.	.	.	.	1
48	.	.	.	.	.	.	1*	.	.		.		.	1	1
49	.	.	.	.	.	.	1*	.	.	.		.	.	1	1
Total	27	6	.	.	.	.	2	.	6	21	5	1	.	2	35
Av. length	39	42	.	.	.	.	49	.	38	40	41	43	.	49	

Date	March 14, 1926	Locality	S. Georgia
St. No.	24	Position	Cumberland Bay
Net	N 100 H 60–(0) m.	Surface T.	circa 2·67° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
35	2	.	.	.	.	.	.	.	1	1	.	.	.	.	2
36	2	.	.	.	.	.	.	.	.	2	.	.	.	.	2
37	2	.	.	.	.	.	.	.	.	2	.	.	.	.	2
38	5	.	.	.	.	.	.	.	2	3	.	.	.	.	5
39	5	.	.	.	.	.	.	.	1	4	.	.	.	.	5
40	14	.	.	.	.	.	.	.	1	9	4	.	.	.	14
41	12	.	.	.	.	.	.	.	5	5	2	.	.	.	12
42	13	.	.	.	.	.	.	.	2	10	1	.	.	.	13
43	8	.	.	.	.	.	.	.	3	2	3	.	.	.	8
44	4	2	.	.	.	.	.	.	.	4	2	.	.	.	6
45	8	1	.	.	.	.	.	.	2	3	4	.	.	.	9
46	1	.	.	.	.	.	.	.	1	.	.	.	.	.	1
47	.	.	.	.	.	.	3*	.	.	.	.	.	.	3	3
48	.	.	.	.	.	.	1*	.	.	.	.	.	.	1	1
49	.	.	.	.	.	.	1*	.	.	.	.	.	.	1	1
55	.	.	.	.	.	.	1*	.	.	.	.	.	.	1	1
Total	76	3	.	.	.	.	6	.	18	45	16	.	.	6	85
Av. length	41	44	.	.	.	.	49	.	41	41	43	.	.	49	

Date	March 19, 1926	Locality	S. Georgia
St. No.	38	Position	Cumberland Bay
Net	N 100 H 50–(0) m.	Surface T.	circa 2·85° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
35	.	1	.	.	.	.	.	.	.	1	.	.	.	.	1
37	.	2	.	.	.	.	.	.	.	2	.	.	.	.	2
38	1	3	.	.	.	.	.	.	2	2	.	.	.	.	4
39	.	3	.	.	.	.	.	.	.	3	.	.	.	.	3
40	.	7	.	.	.	.	.	.	1	5	1	.	.	.	7
41	.	1	2	.	.	.	.	.	.	1	2	.	.	.	3
42	.	3	3	.	.	.	.	.	.	5	1	.	.	.	6
43	.	2	.	.	.	.	.	.	.	2	.	.	.	.	2
44	.	6	.	.	.	.	.	.	.	5	1	.	.	.	6
45	.	3	6	.	.	.	.	.	1	5	2	1	.	.	9
46	.	2	5	.	.	.	.	.	2	4	1	.	.	.	7
Total	1	33	16	.	.	.	.	.	6	35	8	1	.	.	50
Av. length	38	38	44	.	.	.	.	.	42	42	43	45	.	.	

MALES

Date	March 8, 1930	Locality	S. Sandwich Is.
St. No.	368	Position	Southern Thule
Net	N 100 B 146–0 m.	Surface T.	0·11° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
38	.	1	.	.	.	.	.	.	.	1	.	.	.	.	1
40	.	2	.	.	.	.	.	.	1	1	.	.	.	.	2
42	.	.	1	.	.	.	.	.	.	1	.	.	.	.	1
43	.	2	2	.	.	.	.	.	1	3		.	.	.	4
44	.	.	4	.	.	.	.	.	.	2	2	.	.	.	4
45	.	2	4	.	.	.	.	.	1	4	1	.	.	.	6
46	.	1	1	1	.	.	.	.	.	2	1	.	.	.	3
47	.	.	5	.	.	.	.	.	.	4	1	.	.	.	5
48	.	.	1	1	.	.	.	.	.	.	2	.	.	.	2
49	.	.	4	.	.	.	.	.	.	2	2	.	.	.	4
50	.	.	1	3	.	.	.	.	.	1	1	1	1	.	4
51	.	.	.	.	.	1	.	.	.	.	.	.	1	.	1
52	.	.	2	.	.	.	.	.	.	.	2	.	.	.	2
55	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
56	.	.	.	.	.	1	.	.	.	.	.	.	.	1	1
57	.	.	.	.	.	1	.	.	.	.	.	.	.	1	1
58	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
Total	.	8	25	5	.	3	2	.	3	21	12	1	2	4	43
Av. length	.	43	47	49	.	55	57	.	43	45	48	50	51	57	

Date	March 9, 1931	Locality	S. Orkney Is.
St. No.	638	Position	61° 00½′ S, 49° 48½′ W
Net	N 100 B 155–0 m.	Surface T.	−0·20° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
25	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
37	.	.	.	.	1	.	.	.	.	.	.	1	.	.	1
40	.	.	1	.	.	.	.	.	.	.	1	.	.	.	1
43	.	.	1	.	.	.	.	.	.	.	1	.	.	.	1
51	.	.	.	.	.	1	.	.	.	.	.	.	.	1	1
53	.	.	.	.	.	1	.	.	.	.	.	.	.	1	1
Total	1	.	2	.	1	2	.	1	.	.	2	1	.	2	6
Av. length	25	.	42	.	37	52	.	25	.	.	42	37	.	52	

Date	March 9, 1931	Locality	S. Orkney Is.
St. No.	639	Position	61° 57¾′ S, 51° 59′ W
Net	N 70 V 50–0 m. N 50 V 100–0 m.	Surface T.	−0·76° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
25	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
26	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
29	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
Total	2	1	.	.	.	.	.	2	1	.	.	.	.	.	3
Av. length	26	29	.	.	.	.	.	26	29	.	.	.	.	.	

Date	March 10, 1931	Locality	S. Shetland Is.
St. No.	640	Position	61° 26½′ S, 53° 47½′ W
Net	N 100 B 164–0 m.	Surface T.	−0·20° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
23	1	.	.	.	.	.	.	.	1	.	.	.	.	.	1
25	1	.	.	.	.	.	.	.	1	.	.	.	.	.	1
42	.	1	.	.	.	.	.	.	.	1	.	.	.	.	1
Total	2	1	.	.	.	.	.	.	2	1	.	.		.	3
Av. length	24	42	.	.	.	.	.	.	24	42	.	.	.	.	

FEMALES

Date	March 8, 1930	Locality	S. Sandwich Is.
St. No.	368	Position	Southern Thule
Net	N 100 B 146–0 m.	Surface T.	0·11° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
36	1	.	.	.	.	.	.	.	1	.	.	.	.	.	1
37	2	.	.	.	.	.	.	2	.	.	.	.	.	.	2
39	.	.	1	.	.	.	.	1	.	.	.	.	.	.	1
40	.	2	.	.	.	.	.	.	2	.	.	.	.	.	2
41	.	2	.	.	.	.	.	.	2	.	.	.	.	.	2
42	.	1	.	.	.	.	.	1	.	.	.	.	.	.	1
43	.	2	2	.	.	.	.	.	2	.	2	.	.	.	4
44	.	2	2	.	.	.	.	1	.	3	.	.	.	.	4
45	.	1	2	1	.	.	.	.	1	2	1	.	.	.	4
46	.	1	1	1	.	.	.	1	.	1	.	1	.	.	3
47	.	1	1	2	.	.	.	.	.	2	2	.	.	.	4
48	.	.	1	3	.	.	.	.	.	1	1	1	1	.	4
49	.	.	.	.	.	.	1*	.	.	.	.	.	.	1	1
50	.	.	.	.	.	.	2*	.	.	.	.	.	1	1	2
51	.	.	.	.	.	.	1*	.	.	.	.	.	.	1	1
52	.	.	.	.	.	.	2*	.	.	.	.	.	.	2	2
53	.	.	.	.	.	.	2*	.	.	.	.	.	.	2	2
54	.	.	.	.	.	.	3*	.	.	.	.	.	1	2	3
55	.	.	.	.	.	.	2*	.	.	.	.	.	.	2	2
56	.	.	.	.	.	.	2*	.	.	.	.	.	.	2	2
60	.	.	.	.	.	.	1*	.	.	.	.	.	.	1	1
Total	3	12	10	7	.	.	16	6	8	9	6	2	3	14	48
Av. length	37	43	44	47	.	.	53	41	41	46	46	47	51	54	

Date	March 9, 1931	Locality	S. Orkney Is.
St. No.	638	Position	61° 00½′ S, 49° 48½′ W
Net	N 100 B 155–0 m.	Surface T.	−0·20° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
32	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
34	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
36	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
46	.	.	.	.	.	.	1*	.	.	.	.	.	.	1	1
48	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
49	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
51	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
52	.	.	.	.	.	.	2	.	.	.	.	.	.	2	2
55	.	.	.	.	.	.	1*	.	.	.	.	.	.	1	1
Total	3	.	.	.	.	.	7	3	.	.	.	.	.	7	10
Av. length	34	.	.	.	.	.	52	34	.	.	.	.	.	52	

Date	March 9, 1931	Locality	S. Orkney Is.
St. No.	639	Position	61° 57¾′ S, 51° 59′ W
Net	N 70 V 50–0 m.	Surface T.	−0·76° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
25	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
26	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
33	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
Total	3	.	.	.	.	.	.	3	.	.	.	.	.	.	3
Av. length	28	.	.	.	.	.	.	28	.	.	.	.	.	.	

Date	March 10, 1931	Locality	S. Shetland Is.
St. No.	640	Position	61° 26½′ S, 53° 47½′ W
Net	N 100 B 164–0 m.	Surface T.	−0·20° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
25	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
32	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
43	.	.	.	.	.	.	3*	.	.	.	.	.	.	3	3
45	.	.	.	.	.	.	1*	.	.	.	.	.	.	1	1
46	.	.	.	.	.	.	2*	.	.	.	.	.	.	2	2
47	.	.	.	.	.	.	2*	.	.	.	.	.	.	2	2
48	.	.	.	.	.	.	2*	.	.	.	.	.	.	2	2
49	.	.	.	.	.	.	2*	.	.	.	.	.	.	2	2
50	.	.	.	.	.	.	2*	.	.	.	.	.	.	2	2
51	.	.	.	.	.	.	1*	.	.	.	.	.	.	1	1
53	.	.	.	.	.	.	1*	.	.	.	.	.	.	1	1
54	.	.	.	.	.	.	1*	.	.	.	.	.	.	1	1
Total	2	.	.	.	.	.	17	2	.	.	.	.	.	17	19
Av. length	29	.	.	.	.	.	48	29	.	.	.	.	.	48	

MALES

Date March 10, 1931
St. No. 642
Net N 100 B 180–0 m.
Locality S. Shetland Is.
Position {61° 51½' S, 54° 58' W
Surface T. 0·70° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
27	1	.	.	.	.	.	.	.	1	.	.	.	.	.	1
29	1	.	.	.	.	.	.	.	1	.	.	.	.	.	1
32	.	1	.	.	.	.	.	.	.	1	.	.	.	.	1
42	.	.	1	.	.	.	.	.	.	.	1	.	.	.	1
48	.	.	.	.	1	.	.	.	.	.	.	1	.	.	1
Total	2	1	1	.	1	.	.	.	2	1	1	1	.	.	5
Av. length	28	32	42	.	48	.	.	.	28	32	42	48	.	.	

FEMALES

Date March 10, 1931
St. No. 642
Net N 100 B 180–0 m.
Locality S. Shetland Is.
Position {61° 51½' S, 54° 58' W
Surface T. 0·70° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
49	.	.	.	.	.	.	2*	.	.	.	.	.	.	2	2
Total	.	.	.	.	.	.	2	.	.	.	.	.	.	2	2
Av length	.	.	.	.	.	.	49	.	.	.	.	.	.	49	

Date March 10, 1931
St. No. 643
Net N 100 B} N 70 B} 93–0 m.
Locality S. Shetland Is.
Position {61° 44½' S, 56° 07' W
Surface T. 0·60° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
30	.	4	.	.	.	.	.	.	4	.	.	.	.	.	4
33	.	2	.	.	.	.	.	.	2	.	.	.	.	.	2
34	.	5	1	.	.	.	.	.	5	1	.	.	.	.	6
35	.	3	1	.	.	.	.	.	3	1	.	.	.	.	4
36	.	.	3	.	.	.	.	.	.	3	.	.	.	.	3
37	.	.	3	.	.	.	.	.	.	3	.	.	.	.	3
38	.	3	3	.	.	.	.	.	.	6	.	.	.	.	6
39	.	.	1	.	.	.	.	.	.	1	.	.	.	.	1
40	.	2	3	2	.	.	.	.	.	5	2	.	.	.	7
41	.	.	1	2	.	.	.	.	.	.	3	.	.	.	3
42	.	1	.	1	.	.	.	.	.	1	1	.	.	.	2
43	.	.	1	.	.	.	.	.	.	1	.	.	.	.	1
44	.	.	2	.	.	.	.	.	.	.	2	.	.	.	2
45	.	.	1	.	.	.	.	.	.	.	1	.	.	.	1
46	.	.	1	1	1	.	.	.	.	.	2	1	.	.	3
47	.	.	.	1	.	.	.	.	.	.	1	.	.	.	1
48	.	.	.	.	1	.	.	.	.	.	.	1	.	.	1
49	.	.	.	2	3	1	.	.	.	.	2	3	.	1	6
50	.	.	.	2	6	.	.	.	.	.	2	6	.	.	8
51	.	.	.	3	.	.	.	.	.	.	.	3	.	.	3
52	.	.	.	2	1	.	.	.	.	.	.	3	.	.	3
53	.	.	.	.	1	.	.	.	.	.	.	1	.	.	1
54	.	.	.	.	2	1	.	.	.	.	.	1	2	.	3
55	.	.	.	.	1	1	.	.	.	.	.	1	.	1	2
Total	.	20	21	16	16	3	.	.	14	22	16	20	2	2	76
Av. length	.	35	39	47	51	53	.	.	33	38	45	51	54	52	

Date March 10, 1931
St. No. 643
Net N 100 B} N 70 B} 93–0 m.
Locality S. Shetland Is.
Position {61° 44½' S, 56° 07' W
Surface T. 0·60° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
23	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
30	3	.	.	.	.	.	.	1	2	.	.	.	.	.	3
32	1	.	.	.	.	.	.	.	1	.	.	.	.	.	1
33	1	1	.	.	.	.	.	.	2	.	.	.	.	.	2
34	2	3	.	.	.	.	.	2	3	.	.	.	.	.	5
35	8	.	.	.	.	.	.	1	1	3	3	.	.	.	8
36	8	4	.	.	.	.	.	2	3	2	5	.	.	.	12
37	4	1	.	.	.	.	.	1	1	1	2	.	.	.	5
38	3	2	1	.	.	.	.	2	.	1	3	.	.	.	6
39	3	4	.	.	.	.	.	.	4	.	3	.	.	.	7
40	1	4	1	1	.	.	.	.	.	2	2	3	.	.	7
41	.	.	.	1	.	.	.	.	.	.	.	1	.	.	1
42	1	2	.	1	.	.	.	.	.	.	1	3	.	.	4
43	.	.	.	.	1	.	.	.	.	.	1	.	.	.	1
44	.	1	.	1	.	.	.	.	.	.	1	1	.	.	2
45	.	.	.	3	.	.	.	.	.	.	.	3	.	.	3
46	.	.	.	1	.	.	6*	.	.	.	.	1	.	6	7
47	.	.	.	1	.	1	2*	.	.	.	1	1	.	2	4
48	.	.	.	2	.	1	5*	.	.	.	.	3	.	5	8
49	.	.	.	.	.	.	7*	.	.	.	.	.	.	7	7
50	.	.	.	.	.	.	14*	.	.	.	.	.	.	14	14
51	.	.	.	.	.	.	5*	.	.	.	.	.	.	5	5
52	.	.	.	.	.	.	8*	.	.	.	.	.	.	8	8
53	.	.	.	.	.	.	5*	.	.	.	.	.	.	5	5
54	.	.	.	.	.	.	1*	.	.	.	.	.	.	1	1
55	.	.	.	.	.	.	5*	.	.	.	.	.	.	5	5
57	.	.	.	.	.	.	1*	.	.	.	.	.	.	1	1
58	.	.	.	.	.	.	1*	.	.	.	.	.	.	1	1
Total	36	22	2	11	1	2	60	10	17	9	22	16	.	60	134
Av. length	35	38	39	45	43	48	51	34	35	37	38	44	.	51	

Date March 11, 1931
St. No. 644
Net N 100 B 100–0 m.
Locality S. Shetland Is.
Position {61° 20½' S, 56° 40' W
Surface T. 1·51° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
40	.	.	.	.	1	.	.	.	.	.	1	.	.	.	1
48	.	.	.	.	.	2	.	.	.	.	.	.	2	.	2
49	.	.	.	.	.	1	.	.	.	.	.	.	1	.	1
50	.	.	.	.	.	1	.	.	.	.	.	.	.	1	1
52	.	.	.	.	.	2	.	.	.	.	.	.	.	2	2
Total	.	.	.	.	1	6	.	.	.	.	1	.	3	3	7
Av. length	.	.	.	.	40	50	.	.	.	.	40	.	48	51	

Date March 11, 1931
St. No. 644
Net N 100 B 100–0 m.
Locality S. Shetland Is.
Position {61° 20½' S, 56° 40' W
Surface T. 1·51° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
47	.	.	.	.	.	.	3*	.	.	.	.	.	.	3	3
48	.	.	.	.	.	.	3*	.	.	.	.	.	.	3	3
49	.	.	.	.	.	.	2*	.	.	.	.	.	.	2	2
51	.	.	.	.	.	.	2*	.	.	.	.	.	.	2	2
54	.	.	.	.	.	.	1*	.	.	.	.	.	.	1	1
55	.	.	.	.	.	.	2*	.	.	.	.	.	.	2	2
Total	.	.	.	.	.	.	13	.	.	.	.	.	.	13	13
Av. length	.	.	.	.	.	.	50	.	.	.	.	.	.	50	

Date March 11, 1931
St. No. 646
Net N 100 B 155–0 m.
Locality S. Shetland Is.
Position {60° 22½' S, 57° 43' W
Surface T. 2·33° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
48	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
52	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
Total	.	.	.	.	.	.	2	.	.	.	.	.	.	2	2
Av. length	.	.	.	.	.	.	50	.	.	.	.	.	.	50	

Date March 11, 1931
St. No. 646
Net N 100 B 155–0 m.
Locality S. Shetland Is.
Position {60° 22½' S, 57° 43' W
Surface T 2·33° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
43	.	.	.	.	.	.	1*	.	.	.	.	.	.	1	1
47	.	.	.	.	.	.	1*	.	.	.	.	.	.	1	1
48	.	.	.	.	.	.	2*	.	.	.	.	.	.	2	2
51	.	.	.	.	.	.	1*	.	.	.	.	.	.	1	1
Total	.	.	.	.	.	.	5	.	.	.	.	.	.	5	5
Av. length	.	.	.	.	.	.	47	.	.	.	.	.	.	47	

MALES

Date March 26, 1931
St. No. 658
Net N 100 B 120–0 m.
Locality Approaching S. Georgia
Position 53° 38¼′ S., 40° 27¼′ W
Surface T. 2·64° C.

Length in mm.	Stages 1	2	3	4	5	6	7	A	B	C	D	E	F	G	Total in sample
20	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
21	2	.	.	.	.	.	.	2	.	.	.	.	.	.	2
22	2	.	.	.	.	.	.	1	1	.	.	.	.	.	2
23	7	.	.	.	.	.	.	6	1	.	.	.	.	.	7
24	10	1	.	.	.	.	.	10	1	.	.	.	.	.	11
25	11	5	.	.	.	.	.	13	3	.	.	.	.	.	16
26	7	5	.	.	.	.	.	8	4	.	.	.	.	.	12
27	7	5	.	.	.	.	.	5	7	.	.	.	.	.	12
28	1	7	.	.	.	.	.	2	6	.	.	.	.	.	8
29	.	4	.	.	.	.	.	.	4	.	.	.	.	.	4
30	.	3	.	.	.	.	.	.	3	.	.	.	.	.	3
31	.	7	.	.	.	.	.	.	7	.	.	.	.	.	7
32	.	2	.	.	.	.	.	.	2	.	.	.	.	.	2
34	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
35	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
36	.	1	1	.	.	.	.	.	2	.	.	.	.	.	2
40	.	.	.	1	.	.	.	.	.	1	.	.	.	.	1
Total	48	42	1	1	.	.	.	48	43	1	.	.	.	.	92
Av. length	25	29	36	40	.	.	.	25	20	40	.	.	.	.	

Date March 24, 1931
St. No. WS 572
Net N 100 B 190–0 m.
Locality S. Georgia
Position 53° 11½′ S., 37° 41′ W
Surface T. 2·04° C.

Length in mm.	Stages 1	2	3	4	5	6	7	A	B	C	D	E	F	G	Total in sample
21	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
22	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
23	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
24	2	.	.	.	.	.	.	1	1	.	.	.	.	.	2
28	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
29	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
49	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
Total	5	2	.	.	.	.	1	4	3	.	.	.	.	1	8
Av. length	23	29	.	.	.	.	49	23	27	.	.	.	.	49	

Date March 25, 1931
St. No. WS 573
Net N 100 B 124–0 m.
Locality S. Georgia
Position 52° 59¾′ S., 37° 48′ W
Surface T. 2·13° C.

Length in mm.	Stages 1	2	3	4	5	6	7	A	B	C	D	E	F	G	Total in sample
22	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
25	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
Total	2		.	.		.	.	2	.			.	.	.	2
Av. length	24		.	.	.	.	.	24	.	.	.	.	.	.	

Date March 26, 1931
St. No. WS 575
Net N 100 B 78–0 m.
Locality S. Georgia
Position 52° 35′ S., 38° 09′ W
Surface T. 2·82° C.

Length in mm.	Stages 1	2	3	4	5	6	7	A	B	C	D	E	F	G	Total in sample
29	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
30	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
32	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
33	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
36	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
Total	.	5	.	.	.	.	.	.	5	.	.	.	.	.	5
Av. length	.	32	.	.	.	.	.	.	32	.	.	.	.	.	

FEMALES

Date March 26, 1931
St. No. 658
Net N 100 B 120–0 m.
Locality Approaching S. Georgia
Position 53° 38¼′ S., 40° 27¼′ W
Surface T. 2·64° C.

Length in mm.	Stages 1	2	3	4	5	6	7	A	B	C	D	E	F	G	Total in sample
20	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
21	5	.	.	.	.	.	.	5	.	.	.	.	.	.	5
22	6	.	.	.	.	.	.	4	2	.	.	.	.	.	6
23	17	.	.	.	.	.	.	12	5	.	.	.	.	.	17
24	16	.	.	.	.	.	.	8	8	.	.	.	.	.	16
25	25	8	.	.	.	.	.	8	25	.	.	.	.	.	33
26	15	1	.	.	.	.	.	6	10	.	.	.	.	.	16
27	5	8	.	.	.	.	.	.	13	.	.	.	.	.	13
28	7	1	.	.	.	.	.	1	7	.	.	.	.	.	8
29	3	1	.	.	.	.	.	.	4	.	.	.	.	.	4
30	5	1	.	.	.	.	.	.	6	.	.	.	.	.	6
31	2	1	.	.	.	.	.	.	2	1	.	.	.	.	3
32	3	.	.	.	.	.	.	.	3	.	.	.	.	.	3
33	.	2	.	.	.	.	.	.	2	.	.	.	.	.	2
34	.	2	1	.	.	.	.	.	2	1	.	.	.	.	3
35	.	1	.	.	.	.	.	.	1		.	.	.	.	1
36	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
38	.	.	1	.	.	.	.	.	.	.	1	.	.	.	1
48	.	.	.	.	.	.	1*	.	.	.	.	.	.	1	1
Total	110	27	2	.	.	.	1	45	91	2	1	.	.	1	140
Av. length	25	28	36	.	.	.	48	24	27	33	38	.	.	48	

Date March 24, 1931
St. No. WS 572
Net N 100 B 190–0 m
Locality S. Georgia
Position 53° 11½′ S., 37° 41′ W
Surface T. 2·04° C.

Length in mm.	Stages 1	2	3	4	5	6	7	A	B	C	D	E	F	G	Total in sample
21	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
24	2	.	.	.	.	.	.	1	1	.	.	.	.	.	2
25	3	.	.	.	.	.	.	1	2	.	.	.	.	.	3
30	1	.	.	.	.	.	.	.	1	.	.	.	.	.	1
31	1	.	.	.	.	.	.	.	1	.	.	.	.	.	1
Total	8	.	.	.	.	.	.	3	5	.	.	.	.	.	8
Av. length	26	.	.	.	.	.	.	23	27	.	.	.	.	.	

Date March 26, 1931
St. No. WS 575
Net N 100 B 78–0 m.
Locality S. Georgia
Position 52° 35′ S., 38° 09′ W
Surface T. 2·82° C.

Length in mm.	Stages 1	2	3	4	5	6	7	A	B	C	D	E	F	G	Total in sample
22	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
28	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
29	1	.	.	.	.	.	.	.	1	.	.	.	.	.	1
30	1	.	.	.	.	.	.	.	1	.	.	.	.	.	1
31	2	.	.	.	.	.	.	.	2	.	.	.	.	.	2
32	.	3	.	.	.	.	.	.	3	.	.	.	.	.	3
33	.	2	.	.	.	.	.	.	2	.	.	.	.	.	2
34	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
36	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
Total	6	7	.	.	.	.	.	2	11	.	.	.	.	.	13
Av. length	29	33	.	.	.	.	.	25	32	.	.	.	.	.	

MALES

Date	April 1, 1926	Locality	S. Georgia
St. No.	42	Position	Cumberland Bay
Net	N 7–T 120–204 m.	Surface T.	circa 2·08° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
35	.	.	1	.	.	.	.	.	1	.					1
38	.	.	2	.	.	.	.	.	1	1	.		.	.	2
39	.	.	4	1	.	.	.	.	.	3	2		.	.	5
40	.	.	9	1	.	.	.	.	.	8	2	.	.	.	10
41	.	.	5	.	.	.	.	.	.	4	1	.	.	.	5
42	.	.	7	1	.	.	.	.	.	2	6	.	.	.	8
43	.	.	7	3	.	.	.	.	.	4	6	.	.	.	10
44	.	.	9	1	.	.	.	.	.	2	8	.	.	.	10
45	.	.	4	2	.	.	.	.	.	2	4	.	.	.	6
46	.	.	2	1	.	.	.	.	.	.	2	1	.	.	3
47	.	.	4	.	.	.	.	.	.	.	4	.	.	.	4
Total	.	.	54	10	.	.	.	.	2	26	35	1	.	.	64
Av. length	.	.	42	43	.	.	.	.	37	41	43	46	.	.	

Date	April 7, 1927	Locality	Bransfield Strait
St. No.	207 A	Position	62° 54′ 00″ S, 59° 50′ 30″ W
Net	N 70 H 0–5 m	Surface T	From −0·78 to −0·86° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
32	.	.	1	.	.	.	.	.	1	.	.	.	.	.	1
33	.	.	1	.	.	.	.	.	.	1	.	.	.	.	1
35	.	1	3	.	.	.	.	.	3	1	.	.	.	.	4
36	.	.	2	.	.	.	.	.	1	.	1	.	.	.	2
37	.	.	1	.	.	.	.	.	.	1	.	.	.	.	1
38	.	.	3	.	.	.	.	.	.	2	1	.	.	.	3
39	.	.	1	.	.	.	.	.	.	.	1	.	.	.	1
40	.	.	2	.	.	.	.	.	.	.	1	.	1	.	2
42	.	.	3	1	.	.	.	.	.	.	2	2	.	.	4
46	.	.	1	1	.	.	.	.	.	.	1	1	.	.	2
48	.	.	.	.	.	1	.	.	.	.	.	.	1	.	1
49	.	.	.	1	1	1	.	.	.	.	.	2	.	1	3
50	.	.	.	1	2	.	.	.	.	.	.	1	2	.	3
51	.	.	.	.	.	1	.	.	.	.	.	.	1	.	1
52	.	.	.	.	.	1	.	.	.	.	.	.	1	.	1
Total	.	1	18	4	3	4	.	.	5	5	7	6	6	1	30
Av. length	.	35	38	47	50	50	.	.	35	36	40	46	49	49	

Date	April 7, 1927	Locality	Bransfield Strait
St. No.	207 B	Position	62° 54′ 00″ S, 59° 50′ 30″ W
Net	N 70 H 0–5 m.	Surface T.	From −0·78 to −0·86° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
26	1	.	.	.	.	.	.	1	.	.		.	.		1
27	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
28	.	1	.	.	.	.	.	1	.	.	.	.	.	.	1
30	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
31	1	1	.	.	.	.	.	1	1	.	.	.	.	.	2
32	.	4	.	.	.	.	.	1	3	.	.	.	.	.	4
33	.	3	.	.	.	.	.	1	2	.	.	.	.	.	3
34	1	2		.	.	.	.	1	2	.	.	.	.	.	3
35	.	1	4	.	.	.	.	.	3	2	.	.	.	.	5
36	.	.	2	.	.	.	.	.	1	1	.	.	.	.	2
37	.	.	1	.	.	.	.	.	1	.	.	.	.	.	1
38	.	.	1	1	.	.	.	.	1	1	.	.	.	.	2
39	.	.	1	1	.	.	.	.	.	2	.	.	.	.	2
40	.	.	3	.	.	.	.	.	.	2	1	.	.	.	3
41	.	.	3	1	.	.	.	.	.	.	2	2	.	.	4
43	.	.	1	3	.	.	.	.	.	1	1	2	.	.	4
45	.	.	2	.	.	.	.	.	.	.	.	1	1	.	2
52	.	.	.	.	1	.	.	.	.	.	.	.	1	.	1
Total	4	13	18	6	1	.	.	7	15	9	4	5	2	.	42
Av. length	30	32	39	41	52	.	.	30	34	38	41	43	49	.	

FEMALES

Date	April 1, 1926	Locality	S. Georgia
St. No.	42	Position	Cumberland Bay
Net	N 7–T 120–204 m.	Surface T.	circa 2·08° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
36		2								2					2
37		4	1						3	2		.			5
38		1	1							2					2
39			4						2	2					4
40	.	.	6						3	3					6
42	.	.	6	.					4	2					6
43			1							1					1
44		.	1							1					1
Total	.	7	20	.					12	15					27
Av. length	.	37	41	.	.				40	39	.			.	

Date	April 7, 1927	Locality	Bransfield Strait
St. No.	207 A	Position	62° 54′ 00″ S, 59° 50′ 30″ W
Net	N 70 H 0–5 m.	Surface T.	From −0·78 to −0·86° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
30	1		.	.	.	.			.	1	.		.	.	1
31	2		.	.	.	.	.	.	1	1	.	.	.	.	2
32	2	.	.	.	.	.	.		2	.	.	.	.	.	2
33	1	.	.	.	.	.	.		.	1	.	.	.	.	1
35	1	.	.	.	.	.	.		.	1	.	.	.	.	1
36	1	.	.	.	.	.	.		.	1	.	.	.	.	1
39	1	.	.	.	.	.	.	.	.	1	.	.	.	.	1
40	1		.	.	.	.			.	1	.	.	.	.	1
41	1	.	.	.	.	.	1*			1	.	.	.	1	2
43	.			.	.	1	.			.		1	.	.	1
44		.	.	.	.	.	1*		.	.	.		.	1	1
45		.	.	.	.	1	2*	.	.	.	.	1	.	2	3
46	.	.	.	.	.	1	3*		.	.	.	1	.	3	4
47		.	.	.	.	.	7*			.	.	1		6	7
48	.	.	.	.	.	2	4*	.	.	.	.	2		4	6
49	.	.	.	.	.	.	1*		.	.	.			1	1
50	.	.	.	.	.		1*			.		.		1	1
51	.	.	.	.	.		1*			.	.		.	1	1
53	.	.	.	.			1*			.	.	.	.	1	1
Total	11	.		.	.	5	22		3	8	.	6	.	21	38
Av. length	35		.	.		46	47	.	32	36	.	46		47	

Date	April 7, 1927	Locality	Bransfield Strait
St. No.	207 B	Position	62° 54′ 00″ S, 59° 50′ 30″ W
Net	N 70 H 0–5 m.	Surface T.	From −0·78 to −0·86° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
27	1	.	.	.	.	.	.	.	1	.	.	.	.	.	1
28	1	.	.	.	.	.	.	.	1	.	.			.	1
30	4	.	.	.	.	.	.	.	3	1	.	.			4
31	5	.	.	.	.	.	.		1	4	.	.		.	5
32	6	1	.	.	.	.	.		2	5	.	.			7
33	8	.	.	.	.	.	.		4	4	.	.	.		8
34	6	.	.	.	.	.	.		3	2	1	.			6
35	14	1	.	1	.	.	.	.	2	12	2	.			16
36	7	.	.	.	.	.	.	.	2	5	.	.			7
37	2	.	.	2	.	.			.	2		2	.		4
38	.	1	1	1	.	.			1	1	1			.	3
39	.	1	1	.	.	.	.		1	1	.	.	.	.	2
40	.	2	1	1	.	.		.	2	1	.	1	.	.	4
41	.	.	2	.	.	.	1*		.	1	1	.		1	3
42	.	.		.	.	.	2*	.	.	.	.	.	.	2	2
44	.	.	.	.	.	.	1*	.	.	.	.	.	.	1	1
45	.	.	.	.	.	.	4*	.	.	.	.	.	.	4	4
46	.	.	.	.	.	.	1*	.	.	.	.	.	.	1	1
47	.	.	.		.	.	2*	.	.	.	.	.	.	2	2
50		.	.	.	.	.	1*	.	.	.	.	.	.	1	1
52	.	.	.	.	.	.	1*	.	.	.	.	.	.	1	1
Total	54	6	5	5	.	.	13	.	23	39	5	3	.	13	83
Av. length	33	37	40	37	.	.	45	.	34	35	37	38	.	45	

MALES

Date April 7, 1927
St. No 207 C
Net N 70 H 0–5 m
Locality Bransfield Strait
Position 62° 54′·00 S, 59° 50′·30 W
Surface T. From −0·78 to −0·86° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
25	.	1	.	.	.	.	.	1	.	.	.	.	.	.	1
28	1	1	.	.	.	.	.	.	2	.	.	.	.	.	2
29	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
30	.	2	.	.	.	.	.	1	1	.	.	.	.	.	2
31	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
32	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
33	.	3	1	.	.	.	.	1	2	1	.	.	.	.	4
34	.	3	.	.	.	.	.	.	3	.	.	.	.	.	3
36	.	1	1	.	.	.	.	.	1	1	.	.	.	.	2
37	.	1	2	.	.	.	.	.	1	2	.	.	.	.	3
38	.	1	3	.	.	.	.	.	2	2	.	.	.	.	4
39	.	.	3	.	.	.	.	.	1	1	1	.	.	.	3
41	.	.	3	2	.	.	.	.	.	1	4	.	.	.	5
42	.	.	.	2	.	.	.	.	.	1	1	.	.	.	2
44	.	.	1	2	.	.	.	.	.	1	1	1	.	.	3
45	.	.	.	1	.	.	.	.	.	.	.	1	.	.	1
47	.	.	.	4	.	.	.	.	.	.	.	4	.	.	4
50	.	.	.	1	2	.	.	.	.	.	.	2	1	.	3
51	.	.	.	2	.	.	.	.	.	.	.	1	1	.	2
53	.	.	.	.	6	.	.	.	.	.	.	3	3	.	6
Total	1	16	14	14	8	.	.	3	16	10	7	12	5	.	53
Av. length	28	32	39	46	52	.	.	29	33	39	41	49	52	.	

Date April 7, 1927
St. No. 207 D
Net N 70 H 0–5 m.
Locality Bransfield Strait
Position 62° 54′·00 S, 59° 50′·30 W
Surface T. From −0·78 to −0·86° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
30	.	2	.	.	.	.	.	1	1	.	.	.	.	.	2
33	.	1	1	.	.	.	.	1	1	.	.	.	.	.	2
34	.	.	1	.	.	.	.		1	.	.	.	.	.	1
36	.	.	1	.	.	.	.	.	1	.	.	.	.	.	1
38	.	.	1	.	.	.	.	.	.	1	.	.	.	.	1
47	.	.	.	1	.	.	.	.	.	.	.	1	.	.	1
48	.	.	.	1	.	.	.	.	.	.	.	1	.	.	1
49	.	.	.	2	.	.	.	.	.	.	.	1	1	.	2
51	.	.	.	.	.	2	.	.	.	.	.	.	2	.	2
53	.	.	.	.	1	.	.	.	.	.	.	.	1	.	1
54	.	.	.	.	2	.	.	.	.	.	.	.	2	.	2
55	.	.	.	.	2	.	.	.	.	.	.	.	2	.	2
56	.	.	.	.	1	.	.	.	.	.	.	.	1	.	1
Total	.	3	4	4	6	2	.	2	4	1	.	3	9	.	19
Av. length	.	31	35	48	55	51	.	32	33	38	.	48	53	.	

Date April 7, 1927
St. No. 207 E
Net N 70 H 0–5 m.
Locality Bransfield Strait
Position 62° 54′·00 S, 59° 50′·30 W
Surface T. From −0·78° to −0·86° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
40	.	.	1	.	.	.	.	.	.	.	1	.	.	.	1
52	.	.	.	1	.	.	.	.	.	.	.	.	1	.	1
Total	.	.	1	1	.	.	.	.	.	.	1	.	1	.	2
Av. length	.	.	40	52	.	.	.	.	.	.	40	.	52	.	

FEMALES

Date April 7, 1927
St. No. 207 C
Net N 70 H 0–5 m.
Locality Bransfield Strait
Position 62° 54′·00 S, 59° 50′·30 W
Surface T. From −0·78 to −0·86° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
26	1	.	.	.	.	.	.	.	1	.	.	.	.	.	1
28	1	.	.	.	.	.	.	.	.	1	.	.	.	.	1
29	3	.	.	.	.	.	.	.	2	1	.	.	.	.	3
30	6	.	.	.	.	.	.	.	2	4	.	.	.	.	6
31	1	.	.	.	.	.	.	.	.	1	.	.	.	.	1
32	3	.	.	.	.	.	.	.	2	1	.	.	.	.	3
33	5	.	.	.	.	.	.	.	2	3	.	.	.	.	5
34	2	.	.	.	.	.	.	.	.	2	.	.	.	.	2
35	5	.	.	.	.	.	.	.	2	3	.	.	.	.	5
37	3	.	.	.	.	.	.	.	.	3	.	.	.	.	3
38	.	3	1	.	.	.	.	.	.	1	1	2	.	.	4
39	.	3	1	.	.	.	.	.	.	.	2	2	.	.	4
40	.	.	.	3	.	.	.	.	.	.	2	1	.	.	3
41	.	.	.	1	.	.	.	.	.	.	.	1	.	.	1
43	.	.	.	.	.	.	1*	.	.	.	.	.	.	1	1
44	.	.	.	.	.	.	2*	.	.	.	.	.	.	2	2
45	.	.	.	1	.	.	.	.	.	.	.	1	.	.	1
46	.	.	.	.	.	.	3*	.	.	.	.	.	.	3	3
47	.	.	.	.	.	.	4*	.	.	.	.	.	.	4	4
48	.	.	.	.	.	.	3*	.	.	.	.	.	.	3	3
49	.	.	.	.	.	.	3*	.	.	.	.	.	.	3	3
50	.	.	.	.	.	1	4*	.	.	.	.	.	1	4	5
51	.	.	.	.	.	.	1*	.	.	.	.	.	.	1	1
52	.	.	.	.	.	.	1*	.	.	.	.	.	.	1	1
Total	30	6	2	5	.	1	22	.	11	20	5	7	1	22	66
Av. length	32	39	39	41	.	50	48	.	31	33	39	40	50	48	

Date April 7, 1927
St. No. 207 D
Net N 70 H 0–5 m.
Locality Bransfield Strait
Position 62° 54′ 00 S, 59° 50′ 30 W
Surface T. From −0·78° to −0·86° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
27	1	.	.	.	.	.	.	.	1	.	.	.	.	.	1
30	2	.	.	.	.	.	.	.	1	1	.	.	.	.	2
31	3	.	.	.	.	.	.	.	1	2	.	.	.	.	3
32	1	.	.	.	.	.	.	.	.	1	.	.	.	.	1
33	2	.	.	.	.	.	.	.	.	2	.	.	.	.	2
34	2	.	.	.	.	.	.	.	1	1	.	.	.	.	2
36	1	.	.	.	.	.	.	.	.	1	.	.	.	.	1
42	.	.	.	.	.	.	1*	.	.	.	.	.	.	1	1
45	.	.	.	.	.	.	4*	.	.	.	.	.	.	4	4
46	.	.	.	.	.	.	4*	.	.	.	.	.	.	4	4
47	.	.	.	.	.	.	4*	.	.	.	.	.	.	4	4
48	.	.	.	.	.	.	9*	.	.	.	.	.	.	9	9
49	.	.	.	.	.	.	10*	.	.	.	.	.	.	10	10
50	.	.	.	.	.	.	8*	.	.	.	.	.	.	8	8
Total	12	.	.	.	.	.	40	.	4	8	.	.	.	40	52
Av. length	32	.	.	.	.	.	49	.	31	33	.	.	.	49	

Date April 7, 1927
St. No 207 E
Net N 70 H 0–5 m.
Locality Bransfield Strait
Position 62° 54′·00 S, 59° 50′·30 W
Surface T. From −0·78 to −0·86° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
42	.	.	.	.	.	.	1	.	.	.	.	1	.	.	1
44	.	.	2	.	.	.	.	.	.	.	2	.	.	.	2
45	.	.	.	.	.	.	1*	.	.	.	.	.	.	1	1
46	.	.	.	.	.	.	1	.	.	.	.	1	.	.	1
47	.	.	.	.	.	.	1*	.	.	.	.	.	.	1	1
Total	.	.	2	.	.	.	4	.	.	.	2	2	.	2	6
Av. length	.	.	44	.	.	.	45	.	.	.	44	44	.	46	

MALES

Date	April 7, 1927	Locality	Bransfield Strait
St. No.	207 F	Position	62° 54'·00 S, 59° 50'·30 W
Net	N 70 H 0–5 m.	Surface T.	From −0·78 to −0·86° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
29	.	1	.	.	.	.	.	1	.	.	.	.	.	.	1
30	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
31	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
32	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
35	.	1	2	.	.	.	.	.	3	.	.	.	.	.	3
36	.	.	1	.	.	.	.	.	.	1	.	.	.	.	1
39	.	.	1	.	.	.	.	.	.	1	.	.	.	.	1
40	.	.	1	.	.	.	.	.	.	1	.	.	.	.	1
42	.	.	.	1	.	.	.	.	.	.	.	1	.	.	1
48	.	.	.	2	.	.	.	.	.	.	.	1	1	.	2
51	.	.	.	.	1	.	.	.	.	.	.	.	1	.	1
52	.	.	.	1	1	1	.	.	.	.	.	1	2	.	3
53	.	.	.	.	2	.	.	.	.	.	.	.	2	.	2
54	.	.	.	1	3	.	.	.	.	.	.	1	3	.	4
55	.	.	.	.	1	.	.	.	.	.	.	.	1	.	1
56	.	.	.	.	1	.	.	.	.	.	.	.	1	.	1
57	.	.	.	.	1	.	.	.	.	.	.	.	1	.	1
58	.	.	.	.	1	.	.	.	.	.	.	.	1	.	1
Total	1	4	5	5	11	1	.	2	5	3	.	4	13	.	27
Av. length	32	31	37	49	54	52	.	31	33	38	.	49	54	.	

Date	April 7, 1927	Locality	Bransfield Strait
St. No.	207 G	Position	62° 54'·00 S, 59° 50'·30 W
Net	N 70 H 0–5 m.	Surface T.	From −0·78 to −0·86° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
27	.	1	.	.	.	.	.	1	.	.	.	.	.	.	1
Total	.	1	.	.	.	.	.	1	.	.	.	.	.	.	1
Av. length	.	27	.	.	.	.	.	27	.	.	.	.	.	.	

Date	April 7, 1927	Locality	Bransfield Strait
St. No.	207 H	Position	62° 54'·00 S, 59° 50'·30 W
Net	N 70 H 0–5 m.	Surface T.	From −0·78 to −0·86° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
35	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
47	.	.	1	.	.	.	.	.	.	.	1	.	.	.	1
48	.	.	.	1	.	.	.	.	.	.	.	1	.	.	1
50	.	.	.	1	.	.	.	.	.	.	.	.	1	.	1
51	.	.	.	2	1	.	.	.	.	.	.	.	3	.	3
52	.	.	.	.	3	.	.	.	.	.	.	.	3	.	3
53	.	.	.	.	1	.	.	.	.	.	.	.	1	.	1
55	.	.	.	1	.	.	.	.	.	.	.	.	1	.	1
57	.	.	.	1	.	.	.	.	.	.	.	.	1	.	1
Total	.	1	1	6	5	.	.	.	1	.	1	1	10	.	13
Av. length	.	35	47	52	52	.	.	.	35	.	47	48	52	.	

FEMALES

Date	April 7, 1927	Locality	Bransfield Strait
St. No.	207 F	Position	62° 54'·00 S, 59° 50'·30 W
Net	N 70 H 0–5 m.	Surface T.	From −0·78 to −0·86° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
29	1	.	.	.	.	.	.	.	.	1	.	.	.	.	1
30	4	.	.	.	.	.	.	.	.	4	.	.	.	.	4
31	2	.	.	.	.	.	.	.	2	.	.		.	.	2
32	3	.	.	.	.	.	.	.	2	1	.		.	.	3
33	2	.	.	.	.	.	.	.	1	1			.	.	2
34	2	.	.	.	.	.	.	.	1	1	.	.	.	.	2
35	4	.	.	.	.	.	.	.	3	1	.	.	.	.	4
37	2	.	.	.	.	.	.	.	2	.	.	.	.	.	2
38	1	.	.	.	.	.	.	.	.	1	.	.	.	.	1
39	1	.	.	.	.	.	.	.	.	.	.	1	.	.	1
40	1	.	.	.	.	.	.	.	.	1	.	.	.	.	1
42	.	.	.	1	.	.	.	.	.	.	1	.	.	.	1
43	.	.	.	.	.	.	1*	.	.	.	.	.	.	1	1
44	.	.	.	.	.	.	2*	.	.	.	.	.	.	2	2
45	.	.	.	.	.	.	5*	.	.	.	.	.	.	5	5
46	.	.	1	.	.	.	4*	.	.	.	1	.	.	4	5
47	.	.	.	.	.	.	6*	.	.	.	.	.	.	6	6
48	.	.	.	.	.	.	7*	.	.	.	.	.	.	7	7
49	.	.	.	.	.	.	4*	.	.	.	.	.	.	4	4
50	.	.	.	.	.	.	7*	.	.	.	.	.	.	7	7
51	.	.	.	.	.	.	1*	.	.	.	.	.	.	1	1
Total	23	.	1	1	.	.	37	.	11	11	2	1	.	37	62
Av. length	34	.	46	42	.	.	47	.	34	33	44	39	.	47	

Date	April 7, 1927	Locality	Bransfield Strait
St. No.	207 G	Position	62° 54'·00 S, 59° 50'·30 W
Net	N 70 H 0–5 m.	Surface T.	From −0·78 to −0·86° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
40	.	.	1	.	.	.	.	.	.	.	1	.	.	.	1
42	.	.	1	.	.	.	.	.	.	.	.	1	.	.	1
43	.	.	1	.	.	.	.	.	.	.	1	.	.	.	1
45	.	.	1	.	.	.	.	.	.	.	1	.	.	.	1
Total	.	.	4	.	.	.	.	.	.	.	3	1	.	.	4
Av. length	.	.	43	.	.	.	.	.	.	.	43	42	.	.	

Date	April 7, 1927	Locality	Bransfield Strait
St. No.	207 H	Position	62° 54'·00 S, 59° 50'·30 W
Net	N 70 H 0–5 m.	Surface T.	From −0·78 to −0·86° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
30	1	.	.	.	.	.	.	.	.	1	.	.	.	.	1
31	1	.	.	.	.	.	.	.	1	.	.	.	.	.	1
32	2	.	.	.	.	.	.	.	2	.	.	.	.	.	2
33	1	.	.	.	.	.	.	.	1	.	.	.	.	.	1
34	1	.	.	.	.	.	.	.	.	1	.	.	.	.	1
35	1	.	.	.	.	.	.	.	1	.	.	.	.	.	1
43	.	.	.	1	.	.	.	.	.	.	1	.	.	.	1
44	.	.	.	3	.	.	.	.	.	.	3	.	.	.	3
45	.	.	.	1	.	.	2*	.	.	.	.	1	.	2	3
46	.	.	.	4	.	.	2*	.	.	.	2	2	.	2	6
47	.	.	.	.	.	.	3*	.	.	.	.	.	.	3	3
48	.	.	.	.	.	.	4*	.	.	.	.	.	.	4	4
49	.	.	.	.	.	.	2*	.	.	.	.	.	.	2	2
50	.	.	.	.	.	.	4*	.	.	.	.	.	.	4	4
51	.	.	.	.	.	.	2*	.	.	.	.	.	.	2	2
Total	7	.	.	9	.	.	19	.	5	2	6	3	.	19	35
Av. length	32	.	.	45	.	.	48	.	33	32	45	46	.	48	

MALES

Date	April 7, 1927	Locality	Bransfield Strait
St. No.	207 K	Position	62° 54'·00 S, 59° 50'·30 W
Net	N 70 H 0–5 m.	Surface T.	From −0·78 to −0·86° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
25	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
28	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
29	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
30	.	2	.	.	.	.	.	1	1	.	.	.	.	.	2
31	.	1	1	.	.	.	.	1	1	.	.	.	.	.	2
35	.	2	.	.	.	.	.	.	2	.	.	.	.	.	2
38	.	.	1	.	.	.	.	.	1	.	.	.	.	.	1
48	.	.	.	1	.	.	.	.	.	.	.	1	.	.	1
49	.	.	.	2	.	.	.	.	.	.	.	2	.	.	2
50	.	.	.	.	1	.	.	.	.	.	.	.	1	.	1
52	.	.	.	.	1	.	.	.	.	.	.	.	1	.	1
53	.	.	.	.	1	.	.	.	.	.	.	1	.	.	1
Total	2	6	2	3	3	.	.	4	6	.	.	4	2	.	16
Av. length	27	32	35	49	52	.	.	29	33	.	.	50	51	.	

Date	April 7, 1927	Locality	Bransfield Strait
St. No.	207 L	Position	62° 54'·00 S, 59° 50'·30 W
Net	N 70 H 0–5 m	Surface T.	From −0·78 to −0·86° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
18	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
24	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
Total	2	.	.	.	.	.	.	2	.	.	.	.	.	.	2
Av. length	21	.	.	.	.	.	.	21	.	.	.	.	.	.	

Date	April 7, 1927	Locality	Bransfield Strait
St. No.	207 M	Position	62° 50'·00 S, 59° 50'·30 W
Net	N 70 H 0–5 m.	Surface T.	From −0·78 to −0·86° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
32	.	2	.	.	.	.	.	.	2	.	.	.	.	.	2
34	.	2	.	.	.	.	.	.	2	.	.	.	.	.	2
35	.	.	1	.	.	.	.	.	1	.	.	.	.	.	1
38	.	.	.	1	.	.	.	.	.	.	1	.	.	.	1
47	.	.	.	1	.	.	.	.	.	.	.	1	.	.	1
50	.	.	.	.	1	.	.	.	.	.	.	.	1	.	1
51	.	.	.	.	1	.	.	.	.	.	.	.	1	.	1
Total	.	4	1	2	2	.	.	.	5	.	1	1	2	.	9
Av. length	.	33	35	43	51	.	.	.	33	.	38	47	51	.	

Date	April 7, 1927	Locality	Bransfield Strait
St. No.	207 O	Position	62° 54'·00 S, 59° 50'·30 W
Net	N 70 H 0–5 m.	Surface T.	From −0·78 to −0·86° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
28	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
50	.	.	.	.	.	2	.	.	.	.	.	.	2	.	2
53	.	.	.	.	.	1	.	.	.	.	.	.	1	.	1
Total	.	1	.	.	.	3	.	.	1	.	.	.	3	.	4
Av. length	.	28	.	.	.	51	.	.	28	.	.	.	51	.	

FEMALES

Date	April 7, 1927	Locality	Bransfield Strait
St. No.	207 K	Position	62° 54'·00 S, 59° 50'·30 W
Net	N 70 H 0–5 m.	Surface T.	From −0·78 to −0·86° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
29	1	.	.	.	.	.	.	.	1	.	.	.	.	.	1
32	2	.	.	.	.	.	.	.	2	.	.	.	.	.	2
33	1	.	.	.	.	.	.	.	.	1	.	.	.	.	1
34	1	.	.	.	.	.	.	.	1	.	.	.	.	.	1
35	1	.	.	.	.	.	.	.	.	1	.	.	.	.	1
36	3	.	.	.	.	.	.	.	.	3	.	.	.	.	3
38	1	.	.	.	.	.	.	.	.	.	.	1	.	.	1
39	.	1	.	.	.	.	.	.	.	1	.	.	.	.	1
42	.	.	2	.	.	.	.	.	.	.	1	1	.	.	2
43	.	.	1	.	.	.	.	.	.	.	1	.	.	.	1
45	.	.	.	.	.	.	3*	.	.	.	.	.	.	3	3
46	.	.	.	.	.	.	3*	.	.	.	.	.	.	3	3
47	.	.	.	.	.	.	3*	.	.	.	.	.	.	3	3
48	.	.	.	.	.	.	3*	.	.	.	.	.	.	3	3
49	.	.	.	.	.	.	2*	.	.	.	.	.	.	2	2
Total	10	1	3	.	.	.	14	.	4	6	2	2	.	14	28
Av. length	34	39	42	.	.	.	47	.	32	36	43	40	.	47	

Date	April 7, 1927	Locality	Bransfield Strait
St. No.	207 L	Position	62° 54'·00 S, 59° 50'·30 W
Net	N 70 H 0–5 m.	Surface T.	From −0·78 to −0·86° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
31	.	1	.	.	.	.	.	1	.	.	.	.	.	.	1
32	.	1	.	.	.	.	.	1	.	.	.	.	.	.	1
Total	.	2	.	.	.	.	.	2	.	.	.	.	.	.	2
Av. length	.	32	.	.	.	.	.	32	.	.	.	.	.	.	

Date	April 7, 1927	Locality	Bransfield Strait
St. No.	207 M	Position	62° 54'·00 S, 59° 50'·30 W
Net	N 70 H 0–5 m.	Surface T.	From −0·78° to −0·86° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
28	2	.	.	.	.	.	.	.	2	.	.	.	.	.	2
30	2	.	.	.	.	.	.	.	2	.	.	.	.	.	2
31	4	.	.	.	.	.	.	.	1	3	.	.	.	.	4
33	2	.	.	.	.	.	.	.	.	2	.	.	.	.	2
35	1	.	.	.	.	.	.	.	.	1	.	.	.	.	1
40	.	.	1	.	.	.	.	.	.	.	1	.	.	.	1
43	.	.	.	.	.	.	1*	.	.	.	.	.	.	1	1
44	.	.	1	.	.	.	1*	.	.	.	1	.	.	1	2
46	.	.	.	.	.	.	4*	.	.	.	.	.	.	4	4
47	.	.	.	.	.	.	5*	.	.	.	.	.	.	5	5
48	.	.	.	.	.	.	1*	.	.	.	.	.	.	1	1
Total	11	.	2	.	.	.	12	.	5	6	2	.	.	12	25
Av. length	31	.	42	.	.	.	46	.	29	32	42	.	.	46	

Date	April 7, 1927	Locality	Bransfield Strait
St. No.	207 O	Position	62° 54'·00 S, 59° 50'·30 W
Net	N 70 H 0–5 m.	Surface T.	From −0·78° to −0·86° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
26	2	.	.	.	.	.	.	.	2	.	.	.	.	.	2
30	1	.	.	.	.	.	.	.	1	.	.	.	.	.	1
32	2	.	.	.	.	.	.	.	1	1	.	.	.	.	2
34	1	.	.	.	.	.	.	.	1	.	.	.	.	.	1
35	1	.	.	.	.	.	.	.	1	.	.	.	.	.	1
Total	7	.	.	.	.	.	.	.	6	1	.	.	.	.	7
Av. length	31	.	.	.	.	.	.	.	31	32	.	.	.	.	

MALES

Date April 14, 1928
St. No. WS 196
Net N 100 B 103–0 m.
Locality S. Georgia
Position 54° 36′ S., 38° 38′ W
Surface T. 2·73° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
24	1	.	.	.	.	.	.	.	1	.	.	.	.	.	1
26	2	1	.	.	.	.	.	.	3	.	.	.	.	.	3
27	1	2	.	.	.	.	.	1	2	.	.	.	.	.	3
28	.	4	.	.	.	.	.	.	4	.	.	.	.	.	4
29	.	3	.	.	.	.	.	.	3	.	.	.	.	.	3
30	.	7	.	.	.	.	.	.	7	.	.	.	.	.	7
31	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
32	.	4	.	.	.	.	.	.	4	.	.	.	.	.	4
33	.	.	1	.	.	.	.	.	1	.	.	.	.	.	1
34	.	2	2	.	.	.	.	.	4	.	.	.	.	.	4
36	.	.	1	.	.	.	.	.	1	.	.	.	.	.	1
40	.	.	.	1	.	.	.	.	.	1	.	.	.	.	1
46	.	.	.	1	.	.	.	.	.	1	.	.	.	.	1
48	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
Total	4	24	4	2	.	.	1	1	31	2	.	.	.	1	35
Av. length	26	30	34	43	.	.	48	27	30	43	.	.	.	48	

Date April 28, 1929
St. No. WS 427
Net N 100 B 140–0 m.
Locality S. Georgia
Position 53° 34′ S., 40° 10′ W
Surface T. 1·04° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
48	.	.	.	1	.	.	.	.	.	.	.	1	.	.	1
50	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
54	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
Total	.	.	.	1	.	.	2	.	.	.	.	1	.	2	3
Av. length	.	.	.	48	.	.	52	.	.	.	.	48	.	52	

Date April 5, 1931
St. No. 663
Net TYF V 250–0 m.
Locality S. Georgia
Position 53° 34½′ S., 30° 25¼′ W
Surface T. 0·51° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
25	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
27	1	1	.	.	.	.	.	1	1	.	.	.	.	.	2
29	1	.	.	.	.	.	.	.	1	.	.	.	.	.	1
31	4	.	.	.	.	.	.	2	2	.	.	.	.	.	4
33	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
34	.	2	.	.	.	.	.	.	2	.	.	.	.	.	2
35	1	1	.	.	.	.	.	1	1	.	.	.	.	.	2
36	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
37	.	4	.	.	.	.	.	.	4	.	.	.	.	.	4
41	.	.	.	1	.	.	.	.	.	.	1	.	.	.	1
44	.	.	.	1	.	.	.	.	.	.	1	.	.	.	1
45	.	.	1	.	.	.	.	.	.	1	.	.	.	.	1
49	.	.	.	.	1	.	.	.	.	.	.	1	.	.	1
50	.	.	.	1	1	.	.	.	.	1	.	.	1	.	2
55	.	.	.	.	.	1	1	.	.	.	.	.	1	1	2
Total	8	10	1	3	2	1	1	5	13	2	2	1	2	1	26
Av. length	30	35	45	45	50	55	55	30	31	48	43	49	53	55	

Date April 17, 1931
St. No. 665
Net TYF B 250–0 m.
Locality S. Georgia
Position 51° 41½′ S., 29° 58¾′ W
Surface T. 2·50° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
23	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
25	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
26	1	1	.	.	.	.	.	1	1	.	.	.	.	.	2
27	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
28	.	4	.	.	.	.	.	.	4	.	.	.	.	.	4
29	.	4	.	.	.	.	.	.	4	.	.	.	.	.	4
30	.	5	.	.	.	.	.	.	5	.	.	.	.	.	5
31	.	4	.	.	.	.	.	.	4	.	.	.	.	.	4
32	.	2	.	.	.	.	.	.	2	.	.	.	.	.	2
33	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
34	.	3	.	.	.	.	.	.	3	.	.	.	.	.	3
35	.	3	.	.	.	.	.	.	2	1	.	.	.	.	3
37	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
38	.	.	1	.	.	.	.	.	1	.	.	.	.	.	1
49	.	.	.	.	1	.	.	.	.	.	.	.	1	.	1
Total	3	29	1	.	1	.	.	3	29	1	.	.	1	.	34
Av. length	25	31	38	.	49	.	.	25	31	35	.	.	49	.	

FEMALES

Date April 14, 1928
St. No. WS 196
Net N 100 B 103–0 m.
Locality S. Georgia
Position 54° 36′ S., 38° 38′ W
Surface T. 2·73° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
23	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
25	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
26	1	2	.	.	.	.	.	1	2	.	.	.	.	.	3
27	2	3	.	.	.	.	.	1	3	1	.	.	.	.	5
28	1	4	.	.	.	.	.	.	5	.	.	.	.	.	5
29	.	4	.	.	.	.	.	2	2	.	.	.	.	.	4
30	.	2	.	.	.	.	.	1	1	.	.	.	.	.	2
31	.	5	.	.	.	.	.	1	4	.	.	.	.	.	5
34	.	2	.	.	.	.	.	.	.	2	.	.	.	.	2
Total	6	22	.	.	.	.	.	8	17	3	.	.	.	.	28
Av. length	26	29	.	.	.	.	.	28	29	32	.	.	.	.	

Date April 5, 1931
St. No. 663
Net TYF V 250–0 m.
Locality S. Georgia
Position 53° 34½′ S., 30° 25¼′ W
Surface T. 0·51° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
23	1	.	.	.	.	.	.	.	1	.	.	.	.	.	1
27	1	.	.	.	.	.	.	.	1	.	.	.	.	.	1
28	1	.	.	.	.	.	.	.	1	.	.	.	.	.	1
29	1	.	2	.	.	.	.	.	3	.	.	.	.	.	3
30	2	.	.	.	.	.	.	.	2	.	.	.	.	.	2
31	2	.	4	.	.	.	.	.	6	.	.	.	.	.	6
32	1	.	.	.	.	.	.	.	1	.	.	.	.	.	1
33	1	.	1	.	.	.	.	.	2	.	.	.	.	.	2
35	1	.	.	.	.	.	.	.	1	.	.	.	.	.	1
36	.	.	1	.	.	.	.	.	1	.	.	.	.	.	1
39	.	.	1	.	.	.	.	.	.	1	.	.	.	.	1
41	.	.	1	.	.	.	.	.	.	.	1	.	.	.	1
44	.	.	1	.	.	.	.	.	.	1	.	.	.	.	1
48	.	.	.	.	.	.	1*	.	.	.	.	.	.	1	1
51	.	.	.	.	.	.	1*	.	.	.	.	.	.	1	1
Total	11	.	11	.	.	.	2	.	19	2	1	.	.	2	24
Av. length	29	.	34	.	.	.	50	.	31	42	41	.	.	50	

Date April 17, 1931
St. No. 665
Net TYF B 250–0 m.
Locality S. Georgia
Position 51° 41½′ S., 29° 58¾′ W
Surface T. 2·50° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
25	3	.	.	.	.	.	.	2	1	.	.	.	.	.	3
26	2	1	.	.	.	.	.	2	1	.	.	.	.	.	3
27	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
28	.	3	.	.	.	.	.	.	3	.	.	.	.	.	3
30	1	3	.	.	.	.	.	.	4	.	.	.	.	.	4
31	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
32	.	3	.	.	.	.	.	.	3	.	.	.	.	.	3
33	.	3	.	.	.	.	.	.	3	.	.	.	.	.	3
34	.	1	.	.	.	.	.	1	.	.	.	.	.	.	1
35	.	3	.	.	.	.	.	.	3	.	.	.	.	.	3
36	.	5	.	.	.	.	.	.	5	.	.	.	.	.	5
37	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
38	.	1	.	.	.	.	.	.	.	1	.	.	.	.	1
40	.	1	.	.	.	.	.	.	.	1	.	.	.	.	1
55	.	.	.	.	.	.	1*	.	.	.	.	.	.	1	1
Total	6	27	.	.	.	.	1	5	26	2	.	.	.	1	34
Av. length	26	33	.	.	.	.	.	27	32	39	.	.	.	55	

MALES

Date	April 17–18, 1931	Locality	S. Georgia
St. No.	666	Position	49° 58½′ S, 29° 52½′ W
Net	TYF B 320–0 m.	Surface T.	2·71° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
28	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
30	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
41	.	.	1	.	.	.	.	.	.	1	.	.	.	.	1
Total	.	2	1	.	.	.	.	.	2	1	.	.	.	.	3
Av. length	.	29	41	.	.	.	.	.	29	41	.	.	.	.	

Date	May 18, 1929	Locality	S. Georgia
St. No.	WS 434	Position	53° 10′ S, 34° 08′ W
Net	N 100 B 91–0 m.	Surface T.	3·26° C. (?)

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
30	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
31	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
33	.	.	.	1	.	.	.	.	.	.	1	.	.	.	1
34	.	2	.	.	.	.	.	.	2	.	.	.	.	.	2
35	.	.	1	.	.	.	.	.	.	1	.	.	.	.	1
36	.	.	1	.	.	.	.	.	.	1	.	.	.	.	1
39	.	.	1	.	.	.	.	.	.	.	1	.	.	.	1
43	.	.	.	1	.	.	.	.	.	.	1	.	.	.	1
46	.	.	.	1	.	.	.	.	.	.	1	.	.	.	1
Total	.	4	3	3	.	.	.	.	4	2	4	.	.	.	10
Av. length	.	32	37	41	.	.	.	.	32	36	40	.	.	.	

Date	May 6, 1934	Locality	South of Cape Town
St. No.	1359	Position	63° 45′·2 S, 36° 41′·1 E
Net	N 100 H 5–0 m.	Surface T.	−1·37° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
26	1	.	.	.	.	.	.	.	1	.	.	.	.	.	1
27	3	.	.	.	.	.	.	1	2	.	.	.	.	.	3
28	2	1	.	.	.	.	.	1	2	.	.	.	.	.	3
29	2	1	.	.	.	.	.	1	2	.	.	.	.	.	3
30	.	3	.	.	.	.	.	.	3	.	.	.	.	.	3
31	1	3	.	.	.	.	.	1	3	.	.	.	.	.	4
32	.	2	.	.	.	.	.	.	2	.	.	.	.	.	2
33	.	2	.	.	.	.	.	.	2	.	.	.	.	.	2
36	.	4	.	.	.	.	.	.	4	.	.	.	.	.	4
37	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
39	.	.	2	.	.	.	.	.	2	.	.	.	.	.	2
40	.	.	1	.	.	.	.	.	.	1	.	.	.	.	1
41	.	.	1	.	.	.	.	.	.	1	.	.	.	.	1
Total	9	17	4	.	.	.	.	4	24	2	.	.	.	.	30
Av. length	28	32	40	.	.	.	.	29	32	41	.	.	.	.	

FEMALES

Date	May 18, 1929	Locality	S. Georgia
St. No.	WS 434	Position	53° 10′ S, 34° 08′ W
Net	N 100 B 91–0 m.	Surface T.	3·26° C. (?)

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
28	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
29	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
31	.	2	.	.	.	.	.	.	2	.	.	.	.	.	2
34	.	2	.	.	.	.	.	.	1	1	.	.	.	.	2
37	.	2	.	.	.	.	.	.	.	2	.	.	.	.	2
39	.	1	.	.	.	.	.	.	.	1	.	.	.	.	1
40	.	.	1	.	.	.	.	.	.	.	1	.	.	.	1
Total	.	9	1	.	.	.	.	.	5	4	1	.	.	.	10
Av. length	.	33	40	.	.	.	.	.	31	37	40	.	.	.	

Date	May 6, 1934	Locality	South of Cape Town
St. No.	1359	Position	63° 45′·2 S, 36° 41′·1 E
Net	N 100 H 5–0 m.	Surface T.	−1·37° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
22	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
23	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
24	1	.	.	.	.	.	.	1	.	.	.	.	.	.	1
25	2	.	.	.	.	.	.	.	2	.	.	.	.	.	2
26	5	5	.	.	.	.	.	1	9	.	.	.	.	.	10
28	2	2	.	.	.	.	.	.	4	.	.	.	.	.	4
30	5	9	.	.	.	.	.	2	11	1	.	.	.	.	14
31	3	1	.	.	.	.	.	.	4	.	.	.	.	.	4
32	2	2	.	.	.	.	.	1	3	.	.	.	.	.	4
33	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
34	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
35	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
36	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
37	.	1	1	.	.	.	.	.	1	1	.	.	.	.	2
39	.	1	.	.	.	.	.	.	.	1	.	.	.	.	1
40	.	.	1	.	.	.	.	.	.	1	.	.	.	.	1
41	.	.	1	.	.	.	.	.	.	1	.	.	.	.	1
43	.	.	1	.	.	.	.	.	.	.	1	.	.	.	1
45	.	.	1	.	.	.	.	.	.	.	1	.	.	.	1
Total	22	25	5	.	.	.	.	7	38	5	2	.	.	.	52
Av. length	28	31	41	.	.	.	.	27	35	37	44	.	.	.	

MALES

Date June 2, 1936
St. No. 1780
Net N 100 B 114–0 m.
Locality S.E. of Bouvet I.
Position 56° 10'·1 S, 00° 08'·8 W

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
33	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
38	.	.	1	.	.	.	.	.	.	1	.	.	.	.	1
39	.	.	1	.	.	.	.	.	.	.	1	.	.	.	1
42	.	.	.	1	.	.	.	.	.	.	1	.	.	.	1
43	.	.	.	2	.	.	.	.	.	.	2	.	.	.	2
46	.	.	.	1	.	.	.	.	.	.	1	.	.	.	1
Total	.	1	2	4	.	.	.	.	1	1	5	.	.	.	7
Av. length	.	33	39	44	.	.	.	.	33	38	43	.	.	.	

Date June 2, 1936
St. No. 1781
Net N 100 B 128–0 m., 500–150 m., 800–450 m.
Locality S.E. of Bouvet I.
Position 57° 41'·8 S, 00° 19'·8 W

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
30	.	2	.	.	.	.	.	.	2	.	.	.	.	.	2
31	.	.	1	.	.	.	.	.	.	1	.	.	.	.	1
34	.	.	1	.	.	.	.	.	.	1	.	.	.	.	1
35	.	.	1	2	.	.	.	.	.	2	1	.	.	.	3
36	.	.	1	1	.	.	.	.	.	2	.	.	.	.	2
38	.	.	.	1	.	.	.	.	.	.	1	.	.	.	1
40	.	.	2	2	1	.	.	.	.	3	1	1	.	.	5
41	.	.	.	1	.	.	.	.	.	1	.	.	.	.	1
42	.	.	.	1	.	.	.	.	.	.	1	.	.	.	1
43	.	.	.	2	.	.	.	.	.	.	2	.	.	.	2
45	.	.	.	3	.	.	.	.	.	.	3	.	.	.	3
49	.	.	.	2	.	.	.	.	.	.	1	1	.	.	2
Total	.	2	6	15	1	.	.	.	2	10	10	2	.	.	24
Av. length	.	30	36	42	40	.	.	.	30	37	43	45	.	.	

Date June 3, 1936
St. No. 1782
Net N 100 B 500–150 m., 700–400 m.
Locality S.E. of Bouvet I.
Position 58° 44'·6 S, 00° 01'·5 E

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
33	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
35	.	.	1	.	.	.	.	.	.	1	.	.	.	.	1
40	.	.	.	1	.	.	.	.	.	.	1	.	.	.	1
48	.	.	.	1	.	.	.	.	.	.	1	.	.	.	1
Total	.	1	1	2	.	.	.	.	1	1	2	.	.	.	4
Av. length	.	33	35	44	.	.	.	.	33	35	44	.	.	.	

Date June 6, 1936
St. No. 1786
Net TYF B 800–400 m.
Locality S.E. of Bouvet I.
Position 57° 52'·6 S, 11° 14'·7 E

Length in mm	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
37	.	.	1	.	.	.	.	.	.	1	.	.	.	.	1
42	.	.	.	1	.	.	.	.	.	.	1	.	.	.	1
44	.	.	.	1	.	.	.	.	.	.	1	.	.	.	1
Total	.	.	1	2	.	.	.	.	.	1	2	.	.	.	3
Av. length	.	.	37	43	.	.	.	.	.	37	43	.	.	.	

FEMALES

Date June 2, 1936
St. No. 1780
Net N 100 B 114–0 m.
Locality S.E. of Bouvet I.
Position 56° 10'·1 S, 00° 08'·8 W

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
27	1	.	.	.	.	.	.	1	.	.	.	.			1
35	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
43	.	.	1	.	.	.	.	.	.	1	.	.	.		1
44	.	.	1	.	.	.	.	.	.	1	.	.	.	.	1
Total	1	1	2	.	.	.	.	1	1	2	.	.	.	.	4
Av. length	27	35	44	.	.	.	.	27	35	44	.	.	.	.	

Date June 2, 1936
St. No. 1781
Net N 100 B 128–0 m., 500–150 m., 800–450 m.
Locality S.E. of Bouvet I.
Position 57° 41'·8 S, 00° 19'·8 W

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
30	1	1	.	.	.	.	.	.	2	.	.	.	.	.	2
31	1	2	.	.	.	.	.	.	3	.	.	.	.	.	3
32	1	2	.	.	.	.	.	.	3	.	.	.	.	.	3
33	.	4	.	.	.	.	.	.	3	1	.	.	.	.	4
34	.	2	.	.	.	.	.	.	2	.	.	.	.	.	2
35	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
36	.	5	6	.	.	.	.	.	2	9	.	.	.	.	11
37	.	1	4	.	.	.	.	.	.	4	1	.	.	.	5
38	.	.	5	.	.	.	.	.	.	4	1	.	.	.	5
39	.	1	8	.	.	.	.	.	.	7	2	.	.	.	9
40	.	.	10	.	.	.	.	.	.	6	4	.	.	.	10
41	.	1	1	.	.	.	.	.	.	.	2	.	.	.	2
42	.	.	3	.	.	.	.	.	.	.	3	.	.	.	3
43	.	.	4	.	.	.	.	.	.	.	4	.	.	.	4
44	.	1	1	.	.	.	.	.	.	1	1	.	.	.	2
45	.	.	1	.	.	.	.	.	.	.	1	.	.	.	1
46	.	.	4	.	.	.	.	.	.	.	3	1	.	.	4
47	.	.	3	.	.	.	.	.	.	.	.	3	.	.	3
49	.	.	1	.	.	.	.	.	.	.	.	1	.	.	1
Total	3	21	51	.	.	.	.	.	16	32	22	5	.	.	75
Av. length	31	35	41	.	.	.	.	.	32	38	42	47	.	.	

Date June 3, 1936
St. No. 1782
Net N 100 B 500–150 m., 700–400 m.
Locality S.E. of Bouvet I.
Position 58° 44'·6 S, 00° 01'·5 E

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
36	.	1	.	.	.	.	.	.	.	1	.	.	.	.	1
38	.	.	1	.	.	.	.	.	.	.	1	.	.	.	1
40	.	.	1	.	.	.	.	.	.	.	1	.	.	.	1
41	.	1	1	.	.	.	.	.	.	.	2	.	.	.	2
43	.	.	1	.	.	.	.	.	.	.	.	1	.	.	1
49	.	.	1	.	.	.	.	.	.	.	.	1	.	.	1
Total	.	2	5	.	.	.	.	.	.	1	4	2	.	.	7
Av. length	.	39	42	.	.	.	.	.	.	36	40	46	.	.	

Date June 6, 1936
St. No. 1787
Net TYF B 800–400 m.
Locality S.E. of Bouvet I.
Position 58° 05'·9 S, 12° 48'·6 E
Surface T. −1·50° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
39	.	1	.	.	.	.	.	.	.	1	.	.	.	.	1
40	.	.	2	.	.	.	.	.	.	.	2	.	.	.	2
42	.	1	.	.	.	.	.	.	.	1	.	.	.	.	1
Total	.	2	2	.	.	.	.	.	.	2	2	.	.	.	4
Av. length	.	41	40	.	.	.	.	.	.	41	40	.	.	.	

MALES

Date	June 7, 1936	Locality	S.E. of Bouvet I.
St. No.	1788	Position	{59° 11′·7 S, 17° 01′·9 E
Net	N 100 B 270–0 m.	Surface T.	−1·80° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
40	.	.	.	1	.	.	.	.	.	.	1	.	.	.	1
Total	.	.	.	1	.	.	.	.	.	.	1	.	.	.	1
Av. length	.	.	.	40	.	.	.	.	.	.	40	.	.	.	

Date	July 12, 1938	Locality	Cape Town to Ice Edge
St. No.	2362		
Net	{N 100 H 0–5 m., TYFB 450–430 m.	Position	{54° 59′·3 S, 01° 10′·2 E

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
30	.	.	1	.	.	.	.	.	.	1	.	.	.	.	1
35	.	.	.	1	.	.	.	.	.	1	.	.	.	.	1
54	.	.	.	.	.	.	1	.	.	.	.	.	.	1	1
Total	.	.	1	1	.	.	1	.	.	2	.	.	.	1	3
Av. length	.	.	30	35	.	.	54	.	.	33	.	.	.	54	

Date	July 16, 1938	Locality	Cape Town to Ice Edge
St. No.	2372		
Net	N 100 B 102–0 m.	Position	{53° 10′·6 S, 15° 47′·5 E

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
46	.	.	.	.	1	.	.	.	.	.	.	1	.	.	1
48	.	.	.	.	1	.	.	.	.	.	.	1	.	.	1
Total	.	.	.	.	2	.	.	.	.	.	.	2	.	.	2
Av. length	.	.		.	47	.	.	.	.	.	.	47	.	.	

FEMALES

Date	June 7, 1936	Locality	S.E. of Bouvet I.
St. No.	1788	Position	{59° 11′·7 S, 17° 01′·9 E
Net	N 100 B 270–0 m.	Surface T.	−1·80° C.

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
38	.	2	.	.	.	.	.	.	.	1	1	.	.	.	2
Total	.	2	.	.	.	.	.	.	.	1	1	.	.	.	2
Av. length	.	38	.	.	.	.	.	.	.	38	38	.	.	.	

Date	June 10, 1936	Locality	Cape Town to Ice Edge
St. No.	1794		
Net	N 100 B 360–200 m.	Position	{52° 37′·5 S, 18° 22′·7 E

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
47	.	.	1	.	.	.	.	.	.	.	.	1	.	.	1
Total	.	.	1	.	.	.	.	.	.	.	.	1	.	.	1
Av. length	.	.	47	.	.	.	.	.	.	.	.	47	.	.	

Date	July 12, 1938	Locality	Cape Town to Ice Edge
St. No.	2362		
Net	{N 100 H 0–5 m., TYFB 450–430 m.	Position	{54° 59′·3 S, 01° 10′·2 E

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
26	.	1	.	.	.	.	.	1	.	.	.	.	.	.	1
29	.	1	1	.	.	.	.	.	2	.	.	.	.	.	2
30	.	1	.	.	.	.	.	.	1	.	.	.	.	.	1
31	.	.	1	.	.	.	.	.	1	.	.	.	.	.	1
35	.	.	1	.	.	.	.	.	1	.	.	.	.	.	1
40	.	.	1	.	.	.	.	.	.	1	.	.	.	.	1
Total	.	3	4	.	.	.	.	1	5	1	.	.	.	.	7
Av. length	.	28	34	.	.	.	.	26	31	40	.	.	.	.	

Date	July 13, 1938	Locality	Cape Town to Ice Edge
St. No.	2365		
Net	TYFB 350–200 m.	Position	{53° 23′·4 S, 04° 50′·5 E

Length in mm.	Stages														Total in sample
	1	2	3	4	5	6	7	A	B	C	D	E	F	G	
40	.	.	1	.	.	.	.	.	.	.	1	.	.	.	1
41	.	.	2	.	.	.	.	.	.	.	2	.	.	.	2
43	.	.	1	.	.	.	.	.	.	.	1	.	.	.	1
Total	.	.	4	.	.	.	.	.	.	.	4	.	.	.	4
Av. length	.	.	41	.	.	.	.	.	.	.	41	.	.	.	

Table 20. *Egg Measurements from 839 Females*

Date August 28, 1928
St. No. WS 264
Depth N 70 B 97–0 m.

Length in mm.	Egg classes 1	2	3	4	Total
	0·05–0·12	0·13–0·24	0·25–0·48	0·49–0·70	
33	0·05				1
34	0·05 (2)				2
35	0·07				1
36	0·05				1
	0·09				1
	0·07–0·09				1
39	0·07				1
	0·09 (2)				2
40	0·09				1
41	0·09–0·14				1
42		0·18–0·23			1
43	0·09–0·14 (2)	0·18			3
45		0·18			1
		0·18–0·25			1
55		0·23			1
	Total in sample				19
	Average diameter of eggs (mm.)				0·12

Date August 18, 1938
St. No. 2396
Depth N 100 B 109–0 m.

Length in mm.	1	2	3	4	Total
40	0·09				1
	Total in sample				1
	Average diameter of eggs (mm.)				0·09

Date August 19, 1938
St. No. 2399
Depth N 100 H 0–5 m.
N 100 B {98–0 m / 300–150 m.}

Length in mm.	1	2	3	4	Total
33	0·05				1
35	0·05				1
36	0·09				1
38	0·07				1
40	0·09				1
42	0·07				1
	0·09–0·14				1
	Total in sample				7
	Average diameter of eggs (mm.)				0·08

Date August 22, 1938
St. No. 2408
Depth N 100 H 5–0 m
N 100 B } 108–0 m.
N 70 B }

Length in mm.	1	2	3	4	Total
39	0·05				1
40	0·05				1
41	0·05 (4)				4
42	0·07 (2)				2
	Total in sample				8
	Average diameter of eggs (mm.)				0·06

Date August 24, 1938
St. No 2412
Depth N 100 H 5–0 m.
N 100 B 107–0 m

Length in mm.	1	2	3	4	Total
42	0·09				1
	Total in sample				1
	Average diameter of eggs (mm.)				0·09

Date September 5, 1928
St. No WS 277
Depth N 70 B 124–0 m.

Length in mm.	Egg classes 1	2	3	4	Total
	0·05–0·12	0·13–0·24	0·25–0·48	0·49–0·70	
31	0·05				1
33	0·05 (2)				2
35	0·05				1
36	0·05				1
40	0·05–0·07				1
41	0·05–0·07				1
43	0·05–0·07				1
44	0·05–0·07				1
45	0·05–0·07				1
	0·07–0·09				1
46	0·05–0·09				1
48	0·09–0·14				1
49	0·09–0·11	0·09–0·18			2
	Total in sample				15
	Average diameter of eggs (mm.)				0·07

Date September 17, 1928
St. No. WS 282
Depth N 70 B 137–0 m.

Length in mm.	1	2	3	4	Total
33	0·05				1
35	0·05				1
	0·09				1
36	0·05				1
37	0·05				1
38	0·05				1
	0·09 (2)				2
39	0·05				1
42	0·07				1
45	0·09				1
46	0·11				1
51	0·09–0·14				1
52	0·12 (3)				3
55	0·09				1
	Total in sample				17
	Average diameter of eggs (mm.)				

Date September 24, 1938
St. No. 2430
Depth N 100 H 0–5 m.
N 100 B 117–0 m.

Length in mm.	1	2	3	4	Total
42	0·09–0·14				1
46	0·09–0·14				1
	Total in sample				2
	Average diameter of eggs (mm.)				0·12

Date October 2, 1928
St. No. WS 290
Depth N 70 H 0–5 m.

Length in mm.	1	2	3	4	Total
37	0·05				1
	Total in sample				1
	Average diameter of eggs (mm.)				0·05

Date October 4, 1928
St. No. WS 295
Depth N 100 B 97–0 m.

Length in mm.	1	2	3	4	Total
37	0·05				1
	Total in sample				1
	Average diameter of eggs (mm.)				0·05

Date October 5, 1928
St. No. WS 208
Depth N 100 B 94–0 m.

Length in mm.	Egg classes				Total
	1	2	3	4	
	0·05–0·12	0·13–0·24	0·25–0·48	0·49–0·70	
33	0·05	.	.	.	1
34	0·07	.	.	.	1
35	0·09	.	.	.	1
36	0·07	.	.	.	1
38	.	0·18–0·23	.	.	1
39	0·07	.	.	.	2
	0·09	.	.	.	
40	0·09	.	.	.	1
41	0·09	.	.	.	1
42	.	0·14	.	.	1
43	.	0·14	.	.	1
45	.	0·14–0·18	.	.	1
46	0·09	0·18	.	.	2
50	.	0·18	.	.	2
	.	0·23	.	.	
51	.	0·18–0·23	.	.	1
52	.	0·14–0·18	.	.	1
56	.	0·23	.	.	1
		Total in sample			19
		Average diameter of eggs (mm.)			0·13

Date October 6, 1928
St. No. WS 304
Depth N 100 B 110–0 m

30	0·05	.	.	.	1
34	0·05	.	.	.	1
40	0·05	.	.	.	1
44	0·07	.	.	.	1
		Total in sample			4
		Average diameter of eggs (mm.)			0·06

Date October 16–17 1930
St. No. 453
Depth N 100 B 164–0 m.

34	0·05	.	.	.	1
35	0·05	.	.	.	1
		Total in sample			2
		Average diameter of eggs (mm.)			0·05

Date October 17, 1930
St. No. 454
Depth N 70 B 192–0 m.

35	0·05	.	.	.	2
	0·09	.	.	.	
36	0·05 (3)	.	.	.	4
	0·09	.	.	.	
38	0·05	.	.	.	1
39	0·07	.	.	.	3
	0·09 (2)	.	.	.	
40	0·09 (2)	.	.	.	2
42	0·09 (3)	.	.	.	3
43	0·09 (3)	.	.	.	4
	0·11	.	.	.	
44	0·11	.	.	.	1
45	0·09	.	.	.	2
	0·11	.	.	.	
46	0·09		.	.	1
48	0·09	.	.	.	1
49	0·09		.	.	1
50	0·11		.	.	1
51		0·14	.	.	1
		Total in sample			27
		Average diameter of eggs (mm.)			0·09

Date October 18, 1930
St. No. 455
Depth N 100 B 116–0 m.

35	0·07	.	.	.	1
38	0·07	.	.	.	2
	0·09	.	.	.	
44	0·09	.	.	.	1
45	0·09	.	.	.	1
		Total in sample			5
		Average diameter of eggs (mm.)			0·08

Date October 19, 1930
St. No. 459
Depth N 100 B }
N 70 B } 183–0 m.

Length in mm.	Egg classes				Total
	1	2	3	4	
	0·05–0·12	0·13–0·24	0·25–0·48	0·49–0·70	
37	0·05	.	.	.	4
	0·07	.	.	.	
	0·09	.	.	.	
	0·11	.	.	.	
38	0·07 (2)	.	.	.	3
	0·09	.	.	.	
39	0·09 (2)	.	.	.	2
40	0·07	.	.	.	1
		Total in sample			10
		Average diameter of eggs (mm.)			0·07

Date October 22, 1930
St. No. 461 G
Depth N 100 B 700–560 (315) m.

32	0·05	.	.	.	2
	0·07	.	.	.	
33	0·07 (2)	.	.	.	2
34	0·05	.	.	.	3
	0·09	.	.	.	
	0·11	.	.	.	
35	0·05	.	.	.	4
	0·07 (2)	.	.	.	
	0·09	.	.	.	
36	0·05	.	.	.	4
	0·07	.	.	.	
	0·09	.	.	.	
	0·11	.	.	.	
37	0·07 (3)	.	.	.	8
	0·09 (3)	.	.	.	
	0·11 (2)	.	.	.	
38	0·05 (3)	0·14	.	.	8
	0·07 (2)	.	.	.	
	0·11 (2)	.	.	.	
39	0·05 (2)	.	.	.	12
	0·07 (4)	.	.	.	
	0·09 (6)	.	.	.	
40	0·05 (2)	.	.	.	13
	0·07 (5)	.	.	.	
	0·09 (5)	.	.	.	
	0·11	.	.	.	
41	0·05 (3)	0·14 (2)	.	.	11
	0·09 (4)	0·11–0·23	.	.	
	0·11	.	.	.	
42	0·05 (3)	0·14 (2)	.	.	14
	0·07 (3)	.	.	.	
	0·09 (4)	.	.	.	
	0·11 (2)	.	.	.	
43	0·05	0·14	.	.	8
	0·07	.	.	.	
	0·09 (5)	.	.	.	
44	0·05 (2)	0·18	.	.	14
	0·07 (3)	.	.	.	
	0·09 (5)	.	.	.	
	0·11 (3)	.	.	.	
45	0·05 (2)	0·18	.	.	6
	0·07	.	.	.	
	0·09	.	.	.	
	0·11	.	.	.	
46	0·05	0·14 (2)	.	.	7
	0·07	.	.	.	
	0·09 (2)	.	.	.	
	0·11	.	.	.	
47	.	0·15	.	.	2
	.	0·18	.	.	
48	0·09	0·14	.	.	2
50	0·11	.	.	.	1
		Total in sample			121
		Average diameter of eggs (mm.)			0·09

Date October 22, 1930
St. No. 461 D
Depth N 100 B 490–385 m.

36	0·07	.	.	.	1
37	0·11	.	.	.	1
40	0·11	.	.	.	1
49	0·11	.	.	.	1
		Total in sample			4
		Average diameter of eggs (mm.)			0·10

Date October 23, 1930
St. No. 462
Depth N 100 B }
N 70 B } 90–0 m.

40	0·05	.	.	.	1
		Total in sample			1
		Average diameter of eggs (mm.)			0·05

Date October 25, 1930
St. No. 463
Depth N 100 B 132–0 m.

Length in mm.	Egg classes 1	 2	 3	 4	Total
	0·05–0·12	0·13–0·24	0·25–0·48	0·49–0·70	
44	0·09	.	.	.	1
Total in sample					1
Average diameter of eggs (mm.)					0·09

Date October 26, 1930
St. No. 464
Depth N 100 H 67 (–0) m.

48	0·11	.	.	.	1
Total in sample					1
Average diameter of eggs (mm.)					0·11

Date October 26, 1930
St. No. 465
Depth N 100 B 113–0 m.

39	0·05 (2)	.	.	.	2
40	0·07	.	.	.	1
Total in sample					3
Average diameter of eggs (mm.)					0·06

Date November 19, 1929
St. No. WS Alongside Deception I.
Depth N 100 B 0–5 m.

34	.	0·18	.	.	1
38	.	0·14 (3)	.	.	3
48	.	.	0·27	.	1
Total in sample					5
Average diameter of eggs (mm.)					0·17

Eggs recorded at WS 477–WS 487 at depths between 1000–500 m.

2nd nauplii recorded at WS 480–WS 486 at depths between 750–200 m.

Date November 13, 1930
St. No. 480
Depth N 100 B 161–0 m.
N 70 V 1000–750 m.

46	.	.	0·41	.	1
Total in sample					1
Average diameter of eggs (mm.)					0·41

Date November 19, 1930
St. No. 494
Depth N 100 B 160–0 m.

36	.	0·14	.	.	1
37	.	0·14	.	.	2
	.	0·18	.	.	
38	.	0·14 (2)	.	.	2
39	.	0·14	.	.	2
	.	0·18	.	.	
40	.	0·14 (4)	.	.	7
	.	0·18 (3)	.	.	
41	.	0·14 (2)	.	.	3
	.	0·18	.	.	
42	.	0·14 (6)	.	.	6
43	.	0·14 (3)	.	.	8
	.	0·18 (5)	.	.	
44	.	0·14 (6)	.	.	7
	.	0·18	.	.	
45	.	0·14 (2)	.	.	8
	.	0·18 (6)	.	.	
46	.	0·14	.	.	5
	.	0·18 (4)	.	.	
47	.	0·14 (2)	.	.	3
	.	0·18	.	.	
48	.	0·14	.	.	1
49	.	0·14 (4)	.	.	5
	.	0·18	.	.	
51	.	0·14	.	.	1
Total in sample					61
Average diameter of eggs (mm.)					0·15

Date November 29, 1930
St. No. 523
Depth N 100 B 157–0 m.

Length in mm.	Egg classes 1	 2	 3	 4	Total
	0·05–0·12	0·13–0·24	0·25–0·48	0·49–0·70	
41		0·14–0·32			1
44	.	0·18		.	2
	.	0·18–0·27			
45		0·23			1
48	.	.	0·14–0·45	.	1
50		0·18–0·23			1
Total in sample					6
Average diameter of eggs (mm.)					0·23

Date November 6, 1932
St. No. 1009
Depth N 100 B 110–0 m.

27	0·07	.	.	.	1
28	0·07 (2)	.	.	.	2
29	0·07 (2)	.	.	.	2
30	0·07	.	.	.	2
	0·09	.		.	
31	0·07	.			2
	0·09	.		.	
32	0·09 (2)	.	.		2
34	0·11	.		.	1
37	0·09 (2)	0·14 (2)	.		5
	0·11	.			
38	.	0·14	.		2
	.	0·14–0·18			
	.	0·14			2
39	.	0·18	.		
40	.	0·14			1
43	.	0·14		.	1
Total in sample					23
Average diameter of eggs (mm.)					0·11

Date December 19, 1926
St. No. 125
Depth N 100 H 70 m.

43	0·09				1
44	.	0·18			1
45	.	0·18 (2)			3
	.	0·23			
46	.	0·23			1
47	.	0·23			1
48	.	0·18			2
	.	0·23			
49	.	0·18 (2)	.	.	4
	.	0·23 (2)			
50	.	0·14	0·32	.	5
	.	0·18 (2)	.		
	.	0·23	.		
51	.	0·18	.	.	2
	.	0·23	.	.	
52	.	0·23 (2)	0·27	.	3
54	.	0·18 (2)	.	.	6
	.	0·23 (4)	.	.	
55	.	0·18	0·27 (4)	.	13
	.	0·23 (3)	0·32 (3)	.	
	.	.	0·41	.	
	.	.	0·45	.	
56	.	0·18	0·27	.	3
	.	.	0·32	.	
57	.	0·23		0·49	2
58	.	0·18	.	.	1
60	.	.	0·27	.	1
61	.	.	.	0·36–0·64	1
Total in sample					50
Average diameter of eggs (mm.)					0·24

Date December 11, 1930
St. No. 527
Depth N 450 H 122(–0) m.

42	.	.	0·23–0·55	.	1
Total in sample					1
Average diameter in eggs (mm.)					0·30

Date December 17, 1930
St. No. 534
Depth N 100 B 72–0 m.

41	.	0·23	.	.	1
Total in sample					1
Average diameter of eggs (mm.)					0·23

Date December 18, 1930
St. No. 535
Depth N 70 B 0 m.

Length in mm.	Egg classes 1 0·05–0·12	 2 0·13–0·24	 3 0·25–0·48	 4 0·49–0·70	Total
37	.	0·23	0·23–0·45	.	2
44	.	.	0·32	.	1
47	.	.	0·27	.	1
Total in sample					4
Average diameter of eggs (mm.)					0·29

Date December 18, 1930
St. No. 536
Depth N 100 B 122–0 m.

Length in mm.	1	2	3	4	Total
36	.	0·23	.	.	1
Total in sample					1
Average diameter of eggs (mm.)					0·23

Date December 19, 1930
St. No. 538
Depth N 100 B 137–0 m.

Length in mm.	1	2	3	4	Total
48	.	0·23	.	.	1
Total in sample					1
Average diameter of eggs (mm.)					0·23

Eggs and 1st nauplius recorded from St. 537 at (1000–500) m.
Eggs recorded at St. 538 at (750–500) m.

Date December 19, 1930
St. No. 539
Depth N 100 B } 137–0 m.
N 70 B }

Length in mm.	1	2	3	4	Total
30	.	0·23	.	.	1
31	.	0·23 (2)	.		2
32	.	.	0·14–0·36 (2)	.	3
	.	.	0·18–0·32		
35	.	0·23	0·27–0·41	.	2
36	.	.	0·23–0·50	.	1
37	.	.	0·18–0·45	.	1
38	0·09–0·11	.	0·23–0·27 (2)	.	5
	.	.	0·23–0·32	.	
	.	.	0·41–0·45	.	
39	.	.	0·23–0·41	.	2
	.	.	0·23–0·45	.	
40	.	.	0·27–0·55	.	1
41	.	0·23 (2)	.	.	2
42	.	.	0·18–0·32	.	4
	.	.	0·23–0·55	.	
	.	.	0·27–0·41		
	.	.	0·27–0·45		
43	.	.	0·32–0·45	.	1
44	.	0·23	.	.	
45	.	.	0·32–0·45		1
46	.	.	0·23–0·32	.	1
47	.	0·18–0·27	.		1
48	.	.	0·27	.	1
50	.	.	0·27–0·45	.	1
51	.	.	0·23–0·55	.	1
52	.	.	0·18–0·32	.	2
	.	.	0·36	.	
55	.	.	.	0·36–0·64 (2)	2
Total in sample					35
Average diameter of eggs (mm.)					0·32

Eggs and 1st nauplius recorded at St. 539 at (1000–100 m.)

Date December 19, 1930
St. No. 540
Depth N 100 B 155–0 m.
N 70 V 500–250 m.

Length in mm.	1	2	3	4	Total
32	.	0·23	.	.	1
34	.	.	0·27	.	1
Total in sample					2
Average diameter of eggs (mm.)					0·25

Eggs and 2nd nauplius recorded at St. 540 at (500–100) m.

Date December 19–20, 1930
St. No. 541
Depth N 100 B 108–0 m.

Length in mm.	Egg classes 1 0·05–0·12	 2 0·13–0·24	 3 0·25–0·48	 4 0·49–0·70	Total
32	.	0·23	.	.	1
44	.	.	0·27	.	1
Total in sample					2
Average diameter of eggs (mm.)					0·25

Date December 20, 1930
St. No. 546
Depth N 100 B 164–0 m.

Length in mm.	1	2	3	4	Total
46	.	.	0·27	.	1
Total in sample					1
Average diameter of eggs (mm.)					0·27

Eggs and 2nd nauplius recorded at St. 546 at (500–100) m.

Date December 21, 1930
St. No. 548
Depth N 100 B 102–0 m.

Length in mm.	1	2	3	4	Total
39	0·09	0·14	.	.	2
40	.	0·14	.	.	4
	.	0·18	.	.	
	.	0·23 (2)	.	.	
41	.	0·14	.	.	2
	.	0·18	.	.	
43	.	0·14	0·45	.	5
	.	0·18 (3)	.	.	
45	.	0·14 (3)	0·27	.	6
	.	0·18 (2)	.	.	
46	.	0·14	.	.	1
47	.	0·18 (2)	.	.	3
	.	0·23	.	.	
48	.	0·14	.	.	5
	.	0·18	.	.	
	.	0·23 (3)	.	.	
49	.	0·18	.	.	2
	.	0·23	.	.	
50	.	0·18	.	.	3
	.	0·23 (2)	.	.	
52	.	.	0·27	.	1
53	.	0·18	.	.	1
55	.	0·23	.	.	1
Total in sample					36
Average diameter of eggs (mm.)					0·19

Date December 21–22, 1930
St. No. 549
Depth N 100 B 115–0 m.

Length in mm.	1	2	3	4	Total
33	0·09 (2)	.	.	.	2
35	0·09	.	.	.	1
36	0·09	0·14	.	.	2
37	.	0·14 (3)	.	.	3
38	.	0·14 (2)	.	.	2
39	0·09	0·14	.	.	3
	.	0·18	.	.	
40	.	0·14	.	.	3
	.	0·18 (2)	.	.	
41	.	0·18	.	.	2
	.	0·23	.	.	
42	.	0·14	.	.	1
43	0·09	.	.	.	1
44	0·09	0·14	.	.	3
	.	0·18	.	.	
45	.	0·14 (2)	.	.	3
	.	0·18	.	.	
46	.	0·23	.	.	1
47	.	0·18	.	.	1
48	.	0·14	.	.	1
52	.	0·23 (2)	.	.	2
Total in sample					31
Average diameter of eggs (mm.)					0·15

Date December 29, 1930
St. No. 558
Depth N 100 B 146–0 m.

Length in mm.	1	2	3	4	Total
40	.	0·18	.	.	1
	.	0·23 (2)	.	.	2
Total in sample					3
Average diameter of eggs (mm.)					0·21

Eggs and 2nd nauplius recorded at St. 558 at (200–50) m.

Date December 30, 1930
St. No. 559
Depth N 100 B 113–0 m.

	Egg classes				
Length in mm.	1	2	3	4	Total
	0·05–0·12	0·13–0·24	0·25–0·48	0·49–0·70	
33	.	0·18	.	.	1
43	.	0·09–0·18	.	.	1
45	.	0·18	.	.	1
46	.	0·09–0·18	.	.	1
47	.	0·18	.	.	1
Total in sample					5
Average diameter of eggs (mm.)					0·16

Date December 30, 1930
St. No. 560
Depth N 100 B 155–0 m.

37	0·09	.	.	.	1
42	0·09	.	.	.	1
45	.	0·18	.	.	1
47	.	0·23	.	.	1
50	.	.	0·28	.	1
Total in sample					5
Average diameter of eggs (mm.)					0·20

Date December 31, 1930
St. No. 561
Depth N 100 B 137–0 m.

47	.	0·23	.	.	1
50	.	.	0·32	.	1
Total in sample					2
Average diameter of eggs (mm.)					0·28

Date December 31, 1930
St. No. 562
Depth N 100 B 113–0 m.

53	.	.	0·32	.	1
Total in sample					1
Average diameter of eggs (mm.)					0·32

Date January 22, 1929
St. No WS 373 EE
Depth N 100 B 70–0 m.

45	.	0·23	0·45	.	2
47	.	.	0·23–0·45	.	1
48	.	.	0·41–0·45	.	1
49	.	.	0·27	.	6
	.	.	0·32	.	
	.	.	0·45	.	
	.	.	0·36–0·45	.	
	.	.	0·32–0·45	.	
	.	.	0·41–0·50	.	
50	.	.	0·27–0·45	.	3
	.	.	0·36	.	
	.	.	0·32–0·50	.	
51	.	.	0·27–0·32	.	10
	.	.	0·45–0·50	.	
	.	.	0·35–0·41	.	
	.	.	0·27–0·45 (2)	.	
	.	.	0·27–0·32	.	
	.	.	0·45 (4)	.	
52	.	.	0·18–0·45	.	6
	.	.	0·45 (2)	.	
	.	.	0·41–0·50	.	
	.	.	0·36–0·50	.	
	.	.	0·36–0·59	.	
53	.	.	0·32–0·45 (2)	0·45–0·50 (2)	4
54	.	.	0·45 (2)	.	7
	.	.	0·27–0·45	.	
	.	.	0·36–0·45 (2)	.	
	.	.	0·36–0·59	.	
	.	.	0·32–0·50	.	
55	.	.	0·32	.	2
	.	.	0·36–0·45	.	
56	.	.	0·23–0·45	.	1
57	.	.	0·27–0·36	.	1
58	.	.	0·36–0·50	.	1
59	.	.	0·32–0·45	.	1
Total in sample					46
Average diameter of eggs (mm.)					0·40

Date January 21–22, 1930
St. No. 305
Depth N 100 B 100–0 m.

	Egg classes				
Length in mm.	1	2	3	4	Total
	0·05–0·12	0·13–0·24	0·25–0·48	0·49–0·70	
50	.	.	0·32	.	1
51	.	.	0·32	.	1
Total in sample					2
Average diameter of eggs (mm.)					0·32

Date January 24–25, 1930
St. No. 312
Depth N 100 B 150–0 m.

51	.	0·23	.	.	1
Total in sample					1
Average diameter of eggs (mm.)					0·23

Date January 8, 1931
St. No. 576
Depth N 100 B 132–0 m

47	.	.	0·32	.	1
Total in sample					1
Average diameter of eggs (mm.)					0·32

Date January 8, 1931
St. No. 575
Depth N 100 B 97–0 m.

31	.	0·18	.	.	1
33	.	0·18	.	.	1
35	.	0·23 (2)	.	.	2
36	.	0·23	.	.	1
37	.	0·18 (2)	.	.	2
	.	0·18–0·23	.	.	1
	.	0·14–0·27	.	.	1
38	.	0·23	.	.	1
	.	0·27	.	.	1
39	.	0·14–0·23 (3)	.	.	3
40	.	0·23 (3)	0·32	.	4
41	.	.	0·23–0·27	.	1
42	.	0·23	.	.	1
	.	0·14–0·27	.	.	1
43	.	0·09–0·23	.	.	1
	.	0·14–0·23 (2)	.	.	2
44	.	0·23 (2)	0·27 (2)	.	4
45	.	0·23 (2)	0·27	.	3
	.	.	0·36–0·45	.	1
46	.	0·23	0·27	.	2
47	.	.	0·27	.	1
48	.	0·14–0·27	0·27–0·45 (2)	.	3
	.	.	0·36–0·45	.	1
49	.	.	0·23–0·32	.	1
	.	.	0·32	.	1
Total in sample					41
Average diameter of eggs (mm.)					0·25

Date January 10, 1931
St. No. 580
Depth N 100 B 128–0 m.

45	.	.	0·18–0·36	.	1
48	.	.	0·18–0·45	.	1
Total in sample					2
Average diameter of eggs (mm.)					0·30

Date January 12, 1931
St. No. 583
Depth N 100 B 139–0 m.

38	.	0·14	.	.	1
48	.	0·09–0·18	.	.	1
Total in sample					2
Average diameter of eggs (mm.)					0·14

Date January 13, 1931
St. No. 584
Depth N 100 B 165–0 m.

Length in mm.	Egg classes 1	2	3	4	Total
	0·05–0·12	0·13–0·24	0·25–0·48	0·49–0·70	
48	.	.	0·23–0·48	.	1

Total in sample 1
Average diameter of eggs (mm.) 0·34

Eggs recorded at St. 585 at (50–0) m.

Date January 14, 1931
St. No. 590
Depth N 100 B 90–0 m.

48	.	.	0·18–0·45	.	1
50	.	.	0·18–0·45	.	1

Total in sample 2
Average diameter of eggs (mm.) 0·32

Date January 16, 1931
St. No. 596
Depth N 100 B 170–0 m.

43	.	.	0·23–0·45	.	1
45	.	0·23	.	.	1
46	.	0·09–0·18	.	.	1

Total in sample 3
Average diameter of eggs (mm.) 0·24

Date January 17, 1931
St. No. 599
Depth N 100 B 142–0 m.

47	.	.	0·32	.	1
48	.	.	0·18–0·45	.	1
49	.	.	0·23–0·45	.	1

Total in sample 3
Average diameter of eggs (mm.) 0·33

Date January 19, 1931
St. No. 602
Depth N 100 B } 110–0 m.
N 70 B }

42	.	0·23 (2)	.	.	2
43	0·09	.	.	.	1
44	.	0·23 (2)	.	.	2
45	0·09	0·23 (2)	0·23–0·36 (2)	.	5
46	0·09	.	.	.	1
47	.	0·23	.	.	1
48	.	.	0·32–0·55	.	1
50	.	.	0·23–0·41	.	4
	.	.	0·36	.	
	.	.	0·27–0·45	.	
	.	.	0·36–0·45	.	
52	.	.	0·27–0·50	.	2
	.	.	0·36–0·45	.	
53	.	.	0·27	.	4
	.	.	0·32	.	
	.	.	0·36	.	
	.	.	0·23–0·50	.	
54	.	.	0·23–0·45	.	2
	.	.	0·23–0·50	.	
55	.	.	0·09–0·45	.	1
57	.	.	0·23–0·68	.	1
58	.	.	0·23–0·45	.	1

Total in sample 28
Average diameter of eggs (mm.) 0·31

Date January 20, 1931
St. No. 603
Depth N 100 B 140–0 m.

45	.	.	0·18–0·32	.	1
53	.	.	0·18–0·50	.	1
56	.	.	0·18–0·64	.	1

Total in sample 3
Average diameter of eggs (mm.) 0·33

Date January 25–26, 1931
St. No. WS 537
Depth N 100 B 67–0 m.

Length in mm.	Egg classes 1	2	3	4	Total
	0·05–0·12	0·13–0·24	0·25–0·48	0·49–0·70	
47	.	.	0·23–0·25	.	1
51	.	0·23	.	.	1

Total in sample 2
Average diameter of eggs (mm.) 0·25

Date February 22, 1928
St. No. WS 152
Depth N 100 B 110–0 m.

42	.	.	0·27–0·55	.	1
44	.	.	0·32–0·45	.	1
45	.	0·18	0·23–0·55	.	4
	.	0·18–0·23	0·27–0·45	.	
46	.	0·18	0·23–0·36	.	4
	.	0·18–0·23	0·23–0·45	.	
47	.	.	0·23–0·45	.	2
	.	.	0·36–0·55	.	
49	.	.	0·32–0·45 (2)	.	2
50	.	0·18	0·27–0·55	0·45–0·64	3
51	.	.	0·18–0·45	0·45–0·64	4
	.	.	0·45	.	
	.	.	0·36–0·45	.	
52	.	0·23	0·32–0·45	0·45–0·55	4
	.	.	0·41–0·55	.	
53	.	.	0·32	0·45–0·68	2
54	.	.	0·45	0·36–0·68	2
55	.	0·23	0·36–0·55	0·45–0·55	3
56	.	.	0·23–0·45	.	2
	.	.	0·23–0·55	.	
59	.	.	0·36–0·55	.	1
60	.	.	0·23–0·55	.	1

Total in sample 36
Average diameter of eggs (mm.) 0·38

Eggs recorded at St. WS 147 at (250–100) m.

Date February 8, 1929
St. No. WS 376
Depth N 70 V 750–500 m.

50	.	.	.	0·55	1
53	.	.	0·45	.	1

Total in sample 2
Average diameter of eggs (mm.) 0·50

Eggs recorded at St. WS 377 at (100–50) m.

Eggs recorded at St. WS 380 (250–100) m., WS 382 (400–250) m., WS 385 (500–250) m., and WS 394 (200–100) m.

Date February 8, 1930
St. No. 349
Depth N 100 B 60–0 m.
N 70 V 50–0 m.

37	.	0·18	.	.	1
40	.	0·18	.	.	1

Total in sample 2
Average diameter of eggs (mm.) 0·18

Eggs recorded at St. WS 505 at (250–100) m. on Feb. 4, 1930.

Date February 9, 1930
St. No. 351
Depth N 100 B 48–0 m.
N 70 V 100–50 m.

42	.	.	0·41	.	1
45	.	.	0·45	.	1
48	.	.	0·41	.	1
49	.	.	0·45 (3)	.	3
55	.	.	0·45 (2)	.	2

Total in sample 8
Average diameter of eggs (mm.) 0·44

Date February 9, 1930
St. No. 354
Depth N 100 B 96–0 m.

42	.	.	0·32 (2)	.	2
43	.	.	0·45	.	1
46	.	.	0·32	.	1
53	.	.	0·32	0·50	2
54	.	.	0·45	0·50	2
59	.	.	0·45	.	1

Total in sample 9
Average diameter of eggs (mm.) 0·44

Date	February 10, 1930
St. No.	356
Depth	N 70 V 250–100 m.

Length in mm.	Egg classes				Total
	1	2	3	4	
	0·05–0·12	0·13–0·24	0·25–0·48	0·49–0·70	
42	.	.	0·41	.	1
49	.	.	0·45	.	1
50	.	.	.	0·64	1
52	.	.	.	0·55	2
	.	.	.	0·64	
53	.	.	.	0·55	2
	.	.	.	0·59	
55	.	.	.	0·55 (2)	6
	.	.	.	0·59	
	.	.	.	0·64 (3)	
56	.	.	.	0·55	1
57	.	.	.	0·50	3
	.	.	.	0·55	
	.	.	.	0·64	
58	.	.	0·41	0·55	6
	.	.	.	0·59	
	.	.	.	0·63	
	.	.	.	0·64	
59	.	.	.	0·59	3
	.	.	.	0·64	
	.	.	.	0·68	
60	.	.	.	0·50	10
	.	.	.	0·55 (3)	
	.	.	.	0·59 (4)	
	.	.	.	0·64	
	.	.	.	0·68	
61	.	.	.	0·55 (2)	4
	.	.	.	0·59 (2)	
63	.	.	.	0·68	1
64	.	.	.	0·64	1
			Total in sample		42
			Average diameter of eggs (mm.)		0·59

Eggs recorded at a depth of (250–100) m.

Date	February 8, 1931
St. No.	609
Depth	N 100 B 128–0 m.

49	.	.	0·27–0·45	.	1
51	.	.	0·18–0·45	.	1
55	.	.	0·23–0·45	.	1
			Total in sample		3
			Average diameter of eggs (mm.)		0·34

Eggs and metanauplius at St. 618 (Feb. 18–19, 1931) at (750–100) m.
Metanauplius at St. 620 (Feb. 20, 1931) at (1000–500) m.

Date	February 21–22, 1931
St. No.	624
Depth	N 100 B 137–0 m.

48	.	0·18–0·23	.	.	1
			Total in sample		1
			Average diameter of eggs (mm.)		0·21

Date	March 8, 1930
St. No	368
Depth	N 100 B 146–0 m.

45	0·05	.	.	.	1
46	0·07	.	.	.	1
47	0·05	.	.	.	2
	0·07	.	.	.	
48	0·05 (3)	.	.	.	3
			Total in sample		7
			Average diameter of eggs (mm.)		0·05

Eggs recorded at St. 637 (March 8, 1931) at (250–100) m.
Metanauplii recorded at Sts. 636, 637, 638, 639 (March 8–9, 1931) at (1000–0) m.

Date	March 10, 1931
St. No.	643
Depth	N 100 B } N 70 B } 93–0 m.

40	0·05	.	.	.	1
41	0·05	.	.	.	1
42	0·05	.	.	.	1
43	.	0·05–0·23	.	.	1
44	0·05	.	.	.	1
45	0·05 (3)	.	.	.	3
46	0·05	.	.	.	1
47	0·05	.	0·45	.	2
48	0·05 (2)	.	0·23–0·45	.	3
			Total in sample		14
			Average diameter of eggs (mm.)		0·05

Eggs recorded at St. 644 at (250–50) m.
Metanauplius recorded at Sts. 647, 648 at (1000–500) m. and (250–0) m.

Date	April 7, 1927
St. No.	207 A
Depth	N 70 H 0–5 m.

Length in mm.	Egg classes				Total
	1	2	3	4	
	0·05–0·12	0·13–0·24	0·25–0·48	0·49–0·70	
43	.	.	0·45	.	1
45	.	.	0·45	.	1
46	.	.	0·45	.	1
47	.	.	.	0·50	1
48	.	.	0·45 (2)	.	2
			Total in sample		6
			Average diameter of eggs (mm.)		0·46

Date	April 7, 1927
St. No.	207 B
Depth	N 70 H 0–5 m.

35	0·05	.	.	.	1
37	0·05 (2)	.	.	.	2
38	0·05	.	.	.	1
40	0·05	.	.	.	1
			Total in sample		5
			Average diameter of eggs (mm.)		0·05

Date	April 7, 1927
St. No.	207 C
Depth	N 70 H 0–5 m.

40	0·05 (3)	.	.	.	3
41	0·05	.	.	.	1
45	0·05	.	.	.	1
50	.	.	0·45	.	1
			Total in sample		6
			Average diameter of eggs (mm.)		0·12

Date	April 7, 1927
St. No.	207 E
Depth	N 70 H 0–5 m.

42	.	.	.	0·50	1
46	.	.	.	0·59	1
			Total in sample		2
			Average diameter of eggs (mm.)		0·55

Date	April 7, 1927
St. No.	207 F
Depth	N 70 H 0–5 m.

42	0·05	.	.	.	1
			Total in sample		1
			Average diameter of eggs (mm.)		0·05

Date	April 7, 1927
St. No.	207 H
Depth	N 70 H 0–5 m.

43	0·05	.	.	.	1
44	0·05 (3)	.	.	.	3
45	0·05	.	.	.	1
46	0·05 (4)	.	.	.	4
			Total in sample		9
			Average diameter of eggs (mm.)		0·05

Metanauplii recorded at WS 197 (April 17, 1928) at (1000–750) m.

Table 21. *Totals of Males and Females taken in each month, including Fraser's Adolescents*

	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July
Males												
Stage 1	5	7	234	182	297	199	190	63	25	9	—	—
2	37	17	35	40	82	41	316	87	115	21	4	—
3	24	3	23	3	23	27	204	120	125	7	10	1
4	37	4	17	24	27	18	54	41	61	3	24	1
5	48	17	14	13	4	14	12	19	42	—	1	2
6	12	39	80	5	7	3	21	14	11	—	—	—
7	—	5	67	34	169	130	143	5	4	—	—	1
Total	163	92	470	301	609	432	940	349	383	40	39	5
Stage A	18	7	238	199	252	208	60	58	30	4	—	—
B	33	18	31	24	137	42	478	81	135	28	4	—
C	30	3	30	7	10	8	102	78	60	4	13	2
D	29	3	8	19	17	18	66	85	58	4	20	—
E	43	6	12	8	5	12	64	26	39	—	2	2
F	10	49	49	7	14	14	41	7	56	—	—	—
G	—	6	102	37	174	130	129	14	5	—	—	1
Total	163	92	470	301	609	432	940	349	383	40	39	5
Females												
Stage 1	14	18	254	213	338	240	230	275	188	22	4	—
2	66	17	15	18	8	5	304	110	71	34	28	3
3	110	4	54	8	1	2	124	30	50	6	61	8
4	31	33	175	15	12	3	—	18	20	—	—	—
5	5	1	25	78	114	41	10	1	—	—	—	—
6	—	—	—	3	52	92	45	2	6	—	—	—
7	—	—	—	—	4	6	166	129	186	—	—	—
Total	226	73	523	335	529	389	879	565	521	62	93	11
Stage A	20	8	254	212	259	191	267	74	15	7	1	1
B	41	19	5	17	58	43	323	162	146	43	17	5
C	65	10	36	7	29	13	64	121	123	9	38	1
D	71	10	35	10	4	3	11	58	28	3	29	4
E	29	26	187	56	51	4	6	20	25		8	—
F	—	—	4	13	37	27	17	3	1	—	—	—
G	—	—	2	20	91	108	191	127	183	—	—	—
Total	226	73	523	335	529	389	879	565	521	62	93	11

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THE ANTARCTIC CONVERGENCE AND THE DISTRIBUTION OF SURFACE TEMPERATURES IN ANTARCTIC WATERS

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CONTENTS

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By N. A. Mackintosh, D.Sc.

(Plates I–XIV; Text-figs. 1–11)

PART I. THE ANTARCTIC CONVERGENCE

INTRODUCTION

The Antarctic convergence, which constitutes the northern limit of the Antarctic surface water, was first observed by Meinardus (1923), and it is a boundary of far-reaching importance in the Southern Ocean. It may be regarded as the line at the surface along which the Antarctic surface water sinks below the less dense sub-Antarctic water, and it is distinguished by a more or less sharp change of temperature at the surface. The change of temperature is much less clearly defined in some longitudes than in others, but it is probably correct to say that the convergence is continuous around the Southern Ocean, even though there are regions where it can sometimes hardly be traced. It is essentially a feature of the surface, but where it is ill-defined, or when surface temperature records are insufficient, it can usually be assumed to lie in the latitude at which the coldest part of the Antarctic surface layer sinks below 200 m. For further particulars reference should be made to Deacon (1933, pp. 190–3, and 1937, pp. 20–4), and to Böhnecke (1938, p. 201, etc.).

The importance of the convergence does not lie only in the fact that it is the boundary between the two principal water masses at the surface of the Southern Ocean. Its position is also related to the distribution and movements of the deeper water masses, and there are reasons for believing that it has a connexion with meteorological conditions in the Southern Ocean. Furthermore, it has a special biological significance, for the Antarctic and sub-Antarctic zones, between which it forms the boundary, have, in certain respects, a distinct fauna and flora. That is to say, the convergence marks a limit (though not always a very rigid one) to the range of certain species in the plankton (see Hart, 1934, 1937, 1942; Mackintosh, 1934, 1937; John, 1936), the fishes (Norman, 1938) and the benthos (Hastings, 1943). The distribution of diatom ooze and diatomaceous mud as shown on Admiralty charts, and by Neaverson (1934, plate xvii) indicates a relation also between the convergence and the bottom deposits.

A number of oceanic species seem to be unaffected by the convergence, but further investigations will probably increase the list of those whose distribution is influenced by it. It is probable that it separates certain species which characterize different water masses or different systems of circulation, but the simple effect of temperature also needs consideration, for the distribution of some species whose upper or lower limit of tolerance approximates to temperatures at the convergence, may be sharply bounded by the abrupt change of temperature.

Deacon (1937, p. 23) concludes that the latitude of the convergence is determined by the latitude reached by the Antarctic bottom water. He drew the line of the convergence on a circumpolar chart (1937, fig. 4), and this was based on a number of positions fixed in the Falkland sector, and rather more scattered positions in other sectors. Since then a very considerable number of additional positions have been fixed. These show that Deacon's original line must lie very near the actual mean position, but that the position in any given longitude is subject to rather more variation than the earlier data suggested.

Before the mean monthly surface isotherms in Antarctic waters can be drawn it is necessary to locate the mean position of the convergence as correctly as the available data permit. Furthermore, records of both the mean position and the actual position at different times and places, and the change of temperature at the surface, are likely to be required for various purposes in the future, and it therefore seems worth while to publish particulars of every occasion on which the convergence has been crossed by the Discovery Committee's ships, and to indicate the degree of accuracy with which it could on each occasion be located, and the extent of the change of temperature.

DATA

The 'Discovery', 'Discovery II', and 'William Scoresby' have crossed or located the convergence on 139 occasions. In nearly every instance at least some indication of its position was obtained, but the degree of accuracy with which it was located varied considerably according to the observations taken, to the extent to which the convergence was itself recognizable, and to the angle at which it was crossed. The best indication of a crossing of the convergence is a sharp change of temperature shown on the thermograph (see p. 195) an instrument which was in operation at all crossings by the 'Discovery' and by the 'Discovery II', except for a period in the fourth commission (1935–7) of the latter ship. The 'William Scoresby' did not carry a thermograph except on her last commission (1937–8). The other important method of locating the convergence is by vertical stations taken on each side of it, whereby the level of the minimum temperature of the Antarctic surface stratum can be determined. This is a reliable method but is naturally of little value if the stations are very far apart. Sometimes it is evident that the convergence lies between two stations at which only surface temperatures are read, but there must be a clear difference, and of the correct range, if this method is to be trusted. Normally the sea temperature is recorded every four hours as a routine by the ship's personnel. These records are not altogether reliable as exact readings of the temperature, but in the absence of a thermograph they may be of considerable value, especially when they show a sharp change of temperature at about the expected position of the convergence, or when they show where the convergence lies when it is known to have been crossed between two stations some distance apart.

The best determinations of the position of the convergence are obtained when it is crossed approximately at right angles, and the thermograph shows an abrupt change of temperature between two vertical stations of which the more southerly shows a minimum temperature above 200 m. and the more northerly a minimum below 200 m. Such complete indications are not very frequent, though they have commonly been obtained in the Scotia Sea. In many parts of the Southern Ocean it may often be found that there is no clearly defined change of surface temperature, or the change may be obscured by an oblique crossing of the convergence. Sometimes two successive stations may show a minimum temperature at about 200 m., and it is then difficult to know where the true convergence lies. A frequent source of difficulty is the winding course of the convergence. At the surface the junction of Antarctic and sub-Antarctic water seldom lies in a straight line, probably because it is an unstable boundary. It forms twists and loops that may extend as much as 100 miles north or south, and it possibly even forms isolated rings. The line is perhaps comparable to the edge of the pack-ice, and may be even more tortuous. The latitude in which it is found may thus depend partly on whether a ship happens to cross it where it bends to the north or to the south. Another consequence is that a ship steaming in a straight line obliquely across the convergence may pass from Antarctic to sub-Antarctic water and back again several times. It may also happen that before or after a crossing of the convergence, the thermograph indicates that the ship's track passed near to a loop of the convergence without actually cutting it.

It will now be seen that at many crossings of the convergence its position can only be approximately determined. Indeed the exact position in which it is assumed to be is sometimes little more than a matter of opinion. However, even approximate positions are helpful in mapping out the mean position. The latter must always be liable to modification (though in a diminishing degree) in the light of new data.

Table 9 (p. 205) is a list in chronological order of all crossings of the convergence by the Discovery Committee's ships. The position of the convergence is given as nearly as it can be estimated. This may be taken as the middle of a sharp or comparatively gentle temperature gradient at the surface, as half way between two stations at which vertical observations were made, etc. Since some positions could be determined with a good deal more accuracy than others, an indication of the extent to which they can be relied upon is given in the column headed 'Degree of accuracy'. The quality of the evidence on which they are based varies considerably, and it is difficult to assign a very exact meaning to the terms entered in this column. As a rule 'V. good' implies that there was a sharp rise or fall in the thermograph record, clearly identified as the convergence. The possible error in the estimated position is not likely to be more than about 5 miles either way. 'Good' may indicate a thermograph gradient which was well defined, but which extended over some hours of steaming; it may mean that the crossing was unmistakably indicated by the ship's 4-hourly routine temperature readings; or it may be used when there was no definite change at the surface, but when two vertical stations, not too far apart, showed that the convergence lay between them. The maximum error here might be about 20 miles either way. 'Approx.' generally indicates that the convergence may have been crossed anywhere between two points about 50–150 miles apart; or it may be used, for example, where the only evidence was a vertical station with a minimum temperature at or about 200 m., for this does not necessarily mean that the station lay exactly on the convergence. 'Probable' generally implies that there was evidence that the convergence had been crossed at a position which could be determined with some precision, but that it was not completely certain that it was in fact the convergence. The term is often applicable when there are several sharp changes in temperature which may indicate loops in the convergence. 'Uncertain' is applied to any of the less satisfactory records, and may indicate doubt as to the identification of the convergence or as to the accuracy of the estimated position.

In normal times this work might have been undertaken by Dr G. E. R. Deacon, F.R.S. During the war he has been in service with the Admiralty, but we have together reviewed the data on which each position in Table 9 is based, and I am indebted to him for this assistance and for reading through the manuscript of the paper.

THE MEAN POSITION OF THE CONVERGENCE

Many of the positions in Table 9 are from isolated observations, but sometimes the convergence was crossed more than once at positions not far apart and within a few days or weeks. The convergence does not appear to change its position very quickly, and such points can often be joined up so as to give an indication of its course at a given time. Perhaps the best series of crossings were those made in the Falklands sector in the late months of 1934. These are plotted in Fig. 1. The positions numbered 79–85 were observed within a period of less than 6 weeks, and are therefore joined together by one line (see also Fig. 9, p. 201). Nos. 88 and 90 were a few weeks later and are joined by a separate line. The line of the convergence on these occasions may be compared with the mean line in Plate I.

Figs. 2–4 include the positions listed in Table 9 except No. 20 which was vague and unreliable. Different positions have been joined up, wherever it seemed reasonable to do so. This seems to provide the best basis for estimating the mean position of the convergence, and it gives an impression of the extent to which its position is liable to vary. The majority of positions are in the Atlantic sector. Data are still rather scarce elsewhere, and the points plotted in Fig. 4 are joined by lines drawn simply in what appear to be the most probable positions. In Plate I the convergence is drawn to represent as nearly as possible the mean of the lines in Figs. 2–4. Wherever possible the average latitude has been calculated within narrow limits of longitude, and those records which are marked 'Good' or 'V. good' in Table 9, were counted twice in the averages so that some bias should be given to the more reliable data.

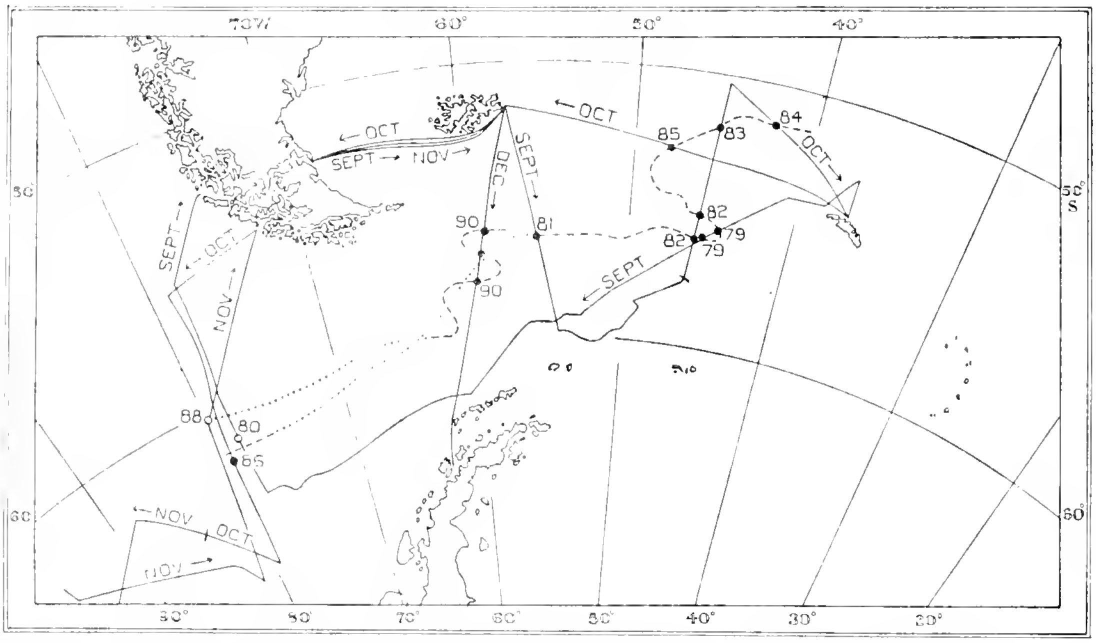

Fig. 1. The Antarctic convergence in the Falkland Islands Sector, September to December 1934. Numbers refer to the serial numbers in Table 9 (p. 205). Black dots denote well-defined positions, and rings approximate or uncertain positions. Pecked lines show the ascertained position of the convergence (apart from unknown minor irregularities), and dotted lines show its probable course where it is not checked. Continuous lines show the tracks of the 'Discovery II' (see also Fig. 9, p. 201).

The mean line of the convergence, shown in Plate I, like most of the results set forth in this paper, is an estimate which is open to adjustment in the light of any additional data which may be obtained in the future. It is obvious from Figs. 2–4 that it is based on far better material between 80° W and 30° E than elsewhere. In the Falkland region the estimated position must be very near the true mean position, but in the Pacific sector, between 110 and 160° W it may be far from accurate.

Some comments are needed on the extent of variation from the mean. I have made a rough measurement of the distance of each plotted point from the estimated mean position, and the resulting figures given in Table 1 are perhaps worth noting. This table includes all the positions in Table 9 for which a measurement could be made, and the possible extent of the displacement may not be so great as it seems to suggest. Most of the larger deviations were at places where either the actual record of the convergence was not very certain, or where the mean position and course of the convergence are based on inadequate data. Furthermore, it is known that sub-Antarctic surface water is sometimes thrust a considerable distance south of the normal position of the convergence, and the extensive loops in the convergence (seen in Figs. 2, 3) show that there is an element of chance in the latitude at which it is found at an isolated crossing. This last factor may indeed account for many instances of apparent displacement from the mean position. Probably a displacement of 50 miles or so either way is not uncommon, but it may be that the extreme displacement does not exceed about 100 miles.

Table 1. *Deviation from the mean position of the convergence*

Miles north or south of mean position	Well-defined positions		All measurable positions	
	Number	%	Number	%
0– 24	31	55	65	49
25– 49	15	27	38	29
50– 74	7	12	14	11
75– 99	1	2	8	6
100–124	1	2	4	3
125–149	1	2	1	1
150–174	0	0	1	1
Total	56	100	131	100

The latitude of the convergence is not much affected by the time of year. Table 2 shows the average deviation for each month. The figures for June, July and August are based on so few records that they should probably be disregarded, and in the other months the average deviation is less than 20 miles except in February. There is a suggestion of a small northerly displacement in the cold months (September–November) and a southerly displacement in the warm months (January–March), but if the latitude of the convergence really varied with the temperature we should not expect the average for April to be so far north. The average monthly deviations are small compared with the actual range of deviation, and the convergence may be found in very different positions even in the same month. For example, Nos. 60 and 109 in Table 9 were both in November in different years and in about the same longitude, but the former crossing was over 50 miles north, and the latter about the same distance south of the mean position. Although there may be a minor seasonal oscillation, it seems probable that variations in the latitude of the convergence depend mainly on local and temporary factors, such as shifting loops and irregularities in its course, and perhaps to variations in winds and currents.

Table 2. *Average monthly deviation from the mean position of the convergence*

Month	Miles north or south of the mean position	Number of instances	Month	Miles north or south of the mean position	Number of instances
September	13 N	9	March	11 S	16
October	10 N	11	April	15 N	16
November	16 N	16	May	12 S	9
December	3 N	17	June	(34 N)	4
January	19 S	9	July	(15 S)	2
February	28 S	17	August	(10 N)	5
				Total	131

As already noted, the mean position of the convergence, drawn in Plate I, does not differ much from that arrived at by Deacon (1937, fig. 4). It is farthest south about 80° W and 180° W, and farthest north between 35° W and 70° E. It is possible that some of the minor bends in its course will be smoothed out in the light of additional data. There is little doubt that the S-shaped turn between the Falkland Islands and South Georgia is a normal feature, but it does not always exist, for there has been at least one occasion when the 'Discovery II' has crossed this region on a meridional course and found no trace of the southern limb of the loop. There is good evidence for the sharp southward turn in 60° W.

New data may suggest a modification of the loop in 30° E, but some distortion of the convergence and isotherms here is probably normal. Deacon (1937, pp. 34 and 92, and plate xliv) refers to a steep ridge on the sea floor at this point, which may affect conditions at the surface. The slight northward bends shown about 140, 97, 75, 67 and 35° W and 110° E need confirmation, and the whole of the convergence between 110 and 160° W, and between 50 and 90° E is based on very little material.

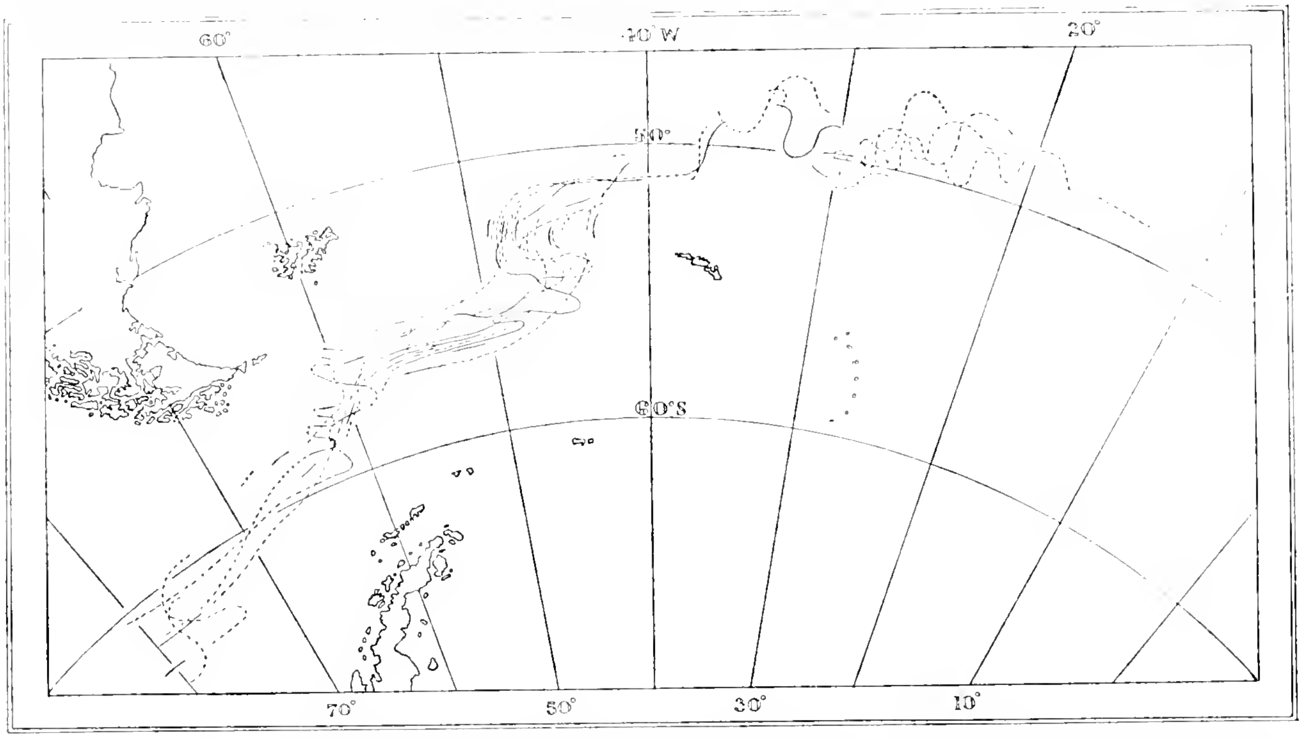

Fig. 2. Positions of the convergence between 10° W and 80° W. Where two or more positions were ascertained within a short period they are joined by a continuous line if the convergence was well defined, and a pecked line if the positions were approximate or uncertain. Single positions are indicated by a short line, continuous or pecked, drawn approximately parallel to the mean line of the convergence.

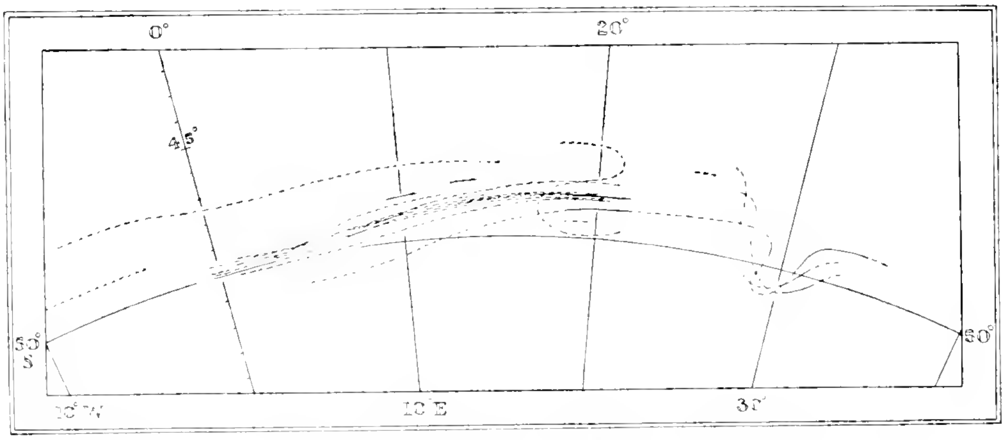

Fig. 3. Positions of the convergence between 10° W and 40° E. See legend to Fig. 2.

It is noteworthy that the convergence divides the Southern Ocean into two almost equal zones; in fact it lies very nearly half way between the Antarctic coastline and the extremities of each of the southern continents. From Cape Agulhas (South Africa) the distance to the convergence is rather less than half the distance to the nearest part of the Antarctic continent, but from Western Australia, Tasmania, New Zealand and Cape Horn the convergence is very close to the half-way point. It is difficult to say whether this is of any special significance. The fact that the convergence lies in about

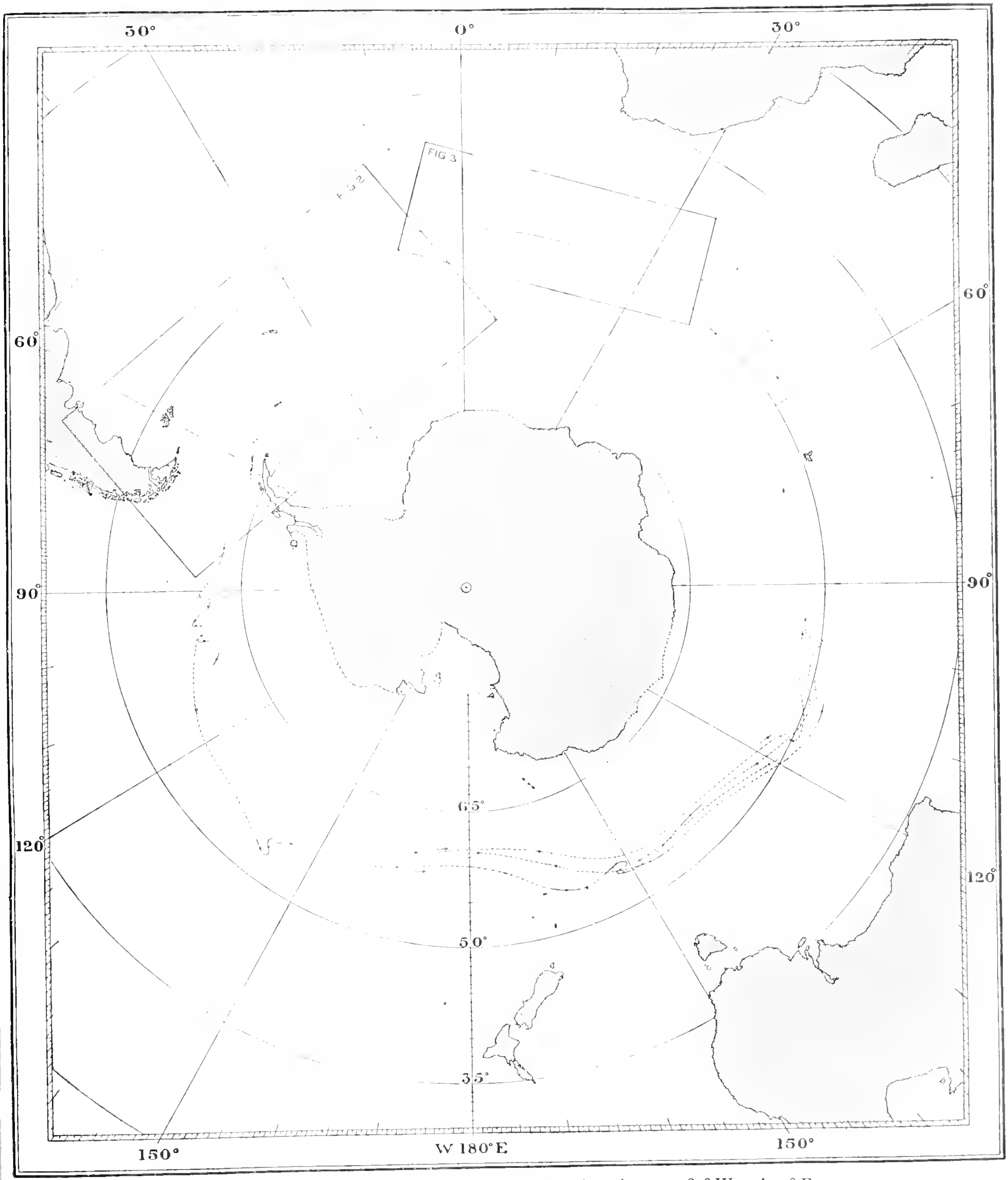

Fig. 4. Positions of the convergence other than those between 80° W and 40° E.

the same relative position at each of these points rather suggests some balance of pressure between water masses drifting through those parts of the Southern Ocean which are limited to the north as well as to the south by land masses. Sverdrup, Johnson and Fleming (1942, p. 607) say: 'The southward displacement of the Antarctic Convergence to the south of Australia and New Zealand can probably be ascribed to the relative narrowness of the passage between these regions and Antarctica, and the similar displacement off South America can be attributed to the southerly location of Drake's Passage separating South America from Graham Land.'

It is also worth while to compare the position of the convergence with the mean northern limit of the pack-ice. The pack extends farthest north about September and October, and the line in Plate I is a reproduction of the September-October line shown by Mackintosh and Herdman (1940, plate lxix). It is evident that the position of this line bears some relation to the position of the convergence. The extreme limit of the ice will of course lie nearer to the convergence, but it is doubtful whether the pack ever reaches the convergence itself.

The distance between the convergence and the mean northern limit of the ice shown in Plate I varies from 120 miles in the Scotia Sea to about 550 miles in the Indian Ocean sector, with an average of 370 miles. This may be taken as a belt which is practically free of pack-ice throughout the year. There is some reason to suppose that it has a characteristic plankton fauna and flora. On the basis of the distribution of macroplankton in the Falkland sector I distinguished a 'northern zone' immediately south of the convergence (1934, p. 150), and Hart (1942, p. 280 and Fig. 2) found that the phytoplankton could be suitably divided into certain biogeographical areas, one of which he took as the 'northern region' lying between the convergence and a line 330 miles to the south of it excepting certain special areas. This region was in fact distinguished largely on the grounds that it is normally free of pack-ice at all times. This is a matter to which I hope to return in a future paper.

THE CHANGE OF TEMPERATURE AT THE SURFACE

The convergence is generally distinguished by a sharp change of temperature at the surface, which usually appears as a steep gradient on the thermograph, and it is important to consider what variations occur in the position of the gradient on the temperature scale, and the range of the gradient. This is best done by examining first the variations in the middle temperature of the gradient, and then the variations in the range. The aim of the present section is to estimate (as nearly as the data permit) what change of temperature we may expect to find in any longitude at any time of year, and hence how to place the isotherms at the convergence when drawing charts of surface temperatures.

Deacon (1933, fig. 10, p. 190) gives an example of the gradient as shown on the thermograph. This was No. 59 in Table 9, and it is an exceptionally well-defined crossing. Some further typical examples are shown here in Fig. 5 A–E. The middle temperature is taken as the mean of the temperatures at the beginning and end of the gradient representing the convergence, or, if the gradient is not very clearly defined, whatever seems best to represent the central temperature of the convergence. It is easy enough to decide the middle temperature and range in such examples as Nos. 33 and 106 (Fig. 5). In such as No. 88 it is difficult, but these small and ill-defined gradients cannot be excluded from calculations of the average. In this case the middle point was taken as 3·0° and the range as 0·8°, on the assumption that the rise of temperature immediately to the right of St. 1476 represented the convergence.

Table 3 is a list of all the middle temperatures and ranges which I have been able to measure. It includes some rather doubtful measurements, such as No. 88, but should serve for provisional estimates of the changes of temperature to be found in different months and positions. Usually both the middle

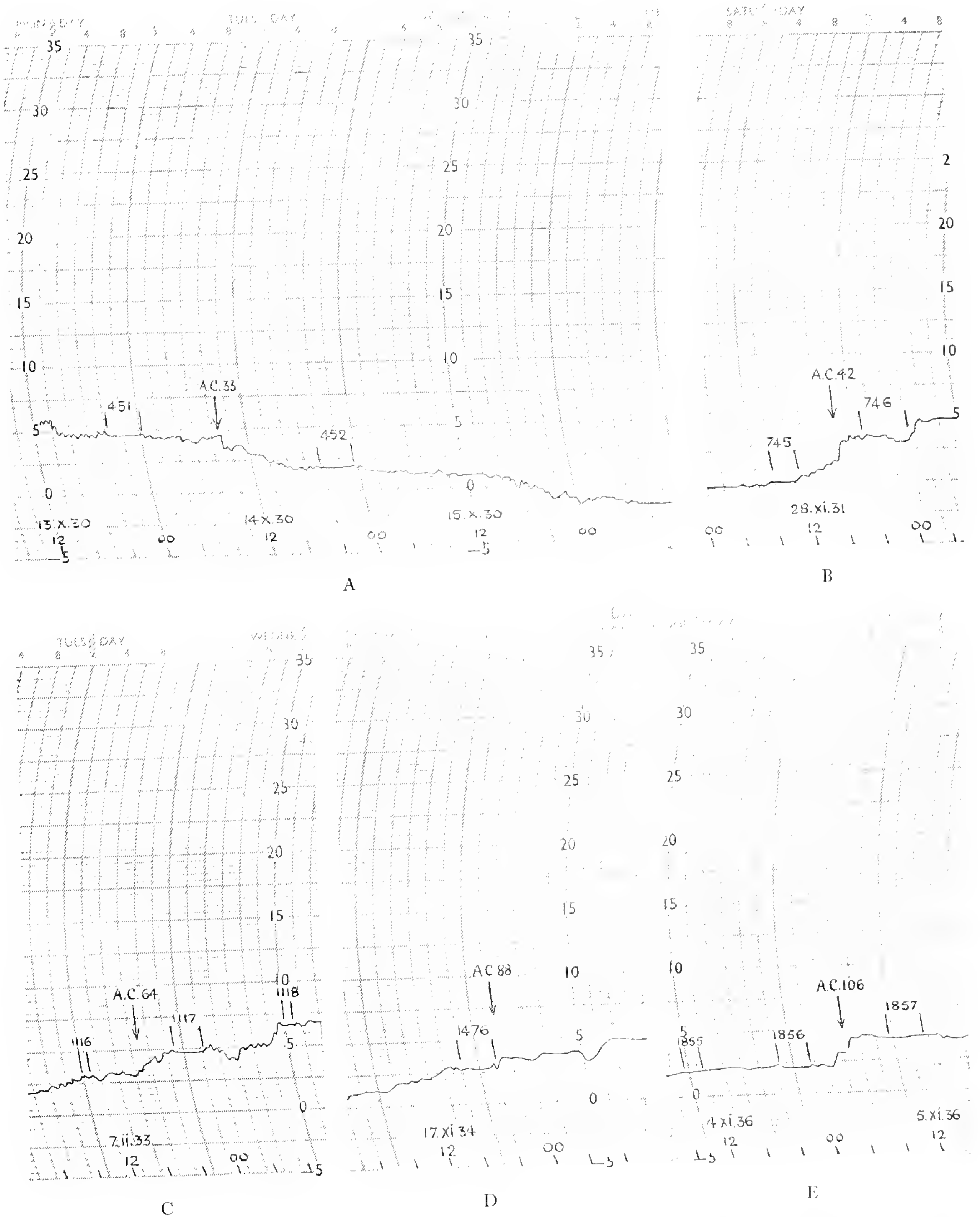

Fig. 5 A–E. Examples of thermograph records crossing the Antarctic convergence, corrected and traced from the original charts. The time scale at the top is G.M.T., and Ship's Time is marked at the foot of each chart. A.C. 33 (etc.) denotes Antarctic convergence, No. 33 in Table 9. Station numbers are shown over the periods during which the ship was stopped or towing nets at slow speed.

temperature and the range are given, but sometimes the former could be distinguished while the beginning and end of the gradient were too ill defined for measurement of the range. In some cases where the change of temperature was small, and the convergence and its gradient could not be distinguished, the middle temperature is omitted, but, for calculating the average, a small figure is entered as an estimate for the range. In one or two other instances an approximate figure could be given for the range though the middle temperature was very obscure (e.g. No. 49).

Table 3. *The change of temperature marking the Antarctic convergence at the surface. Middle temperature and range of the gradient*

Serial number	Middle temperature ° C	Range ° C	Serial number	Middle temperature ° C	Range ° C	Serial number	Middle temperature ° C	Range ° C	Serial number	Middle temperature ° C	Range ° C	Serial number	Middle temperature ° C	Range ° C
1	5·25	2·1	43	2·00	3·2	67	4·00	1·8	91	4·40	—	121	4·00	1·0
3	2·20	—	44	3·80	2·5	68	2·55	1·3	92	4·00	2·6	122	4·50	2·8
4	3·80	0·4	45	4·30	1·7	69	3·20	3·3	94	4·50	2·0	123	4·20	1·4
6	4·50	—	47	4·10	2·2	70	4·50	0·7	95	3·40	0·8	124	4·15	2·5
7	4·90	2·0	48	5·25	2·5	71	4·00	1·1	96	3·40	1·1	125	4·40	1·5
12	2·00	—	49	—	2·0	72	3·50	1·5	99	5·50	—	126	3·50	2·2
13	3·20	—	50	3·10	1·0	73	4·10	3·4	100	5·80	—	127	4·05	1·3
15	5·89	—	51	4·45	1·9	74	4·45	2·3	102	5·30	—	128	3·40	1·4
17	3·80	—	52	3·60	2·2	75	4·50	2·0	103	2·80	—	129	2·85	1·7
22	2·61	—	53	3·45	2·9	76	2·80	2·0	104	2·95	—	130	2·50	1·0
24	—	0·3	54	4·00	4·0	77	2·50	1·0	105	2·00	1·2	131	1·70	1·0
27	4·08	—	55	2·00	1·4	78	3·20	2·4	106	3·15	2·1	132	2·40	1·0
29	3·40	2·8	56	3·75	3·5	79	—	2·4	107	3·50	3·0	133	2·85	0·9
30	3·50	3·0	57	4·25*	1·5	80	1·50	1·5	109	2·15	3·2	134	3·50	1·0
32	5·85	2·7	58	2·00	2·0	81	2·70	2·2	111	4·20	2·0	135	4·50	1·0
33	4·00	1·0	59	1·35	3·5	82	—	1·9	112	5·50	2·0	136	—	0·5
35	—	0·8	60	3·10	3·8	83	1·65	1·3	113	5·50	1·0	137	4·90	0·5
36	—	0·7	61	3·63	1·0	84	1·75	1·1	115	4·50	0·6	138	5·30	0·3
37	4·75	2·5	62	3·85	1·7	85	2·00	2·0	116	3·25	2·3	139	5·15	3·3
38	4·40	1·2	63	3·30	2·4	86	1·30	2·0	117	4·10	1·8			
40	4·25	2·5	64	4·00	1·8	87	2·15	2·1	118	3·50	1·0			
41	2·00	2·0	65	4·50	1·0	88	3·00	0·8	119	4·00	—			
42	2·50	2·0	66	4·90	1·0	90	3·10	3·7	120	4·50	1·5			

* Doubtful.

Analysis of this table indicates that the middle temperature varies mainly according to the time of year, and to some extent according to the latitude of the convergence, while the range varies in different longitudes and appears to depend on other factors.

Taking the middle temperature first, Table 4 gives the average and maximum and minimum values for each month in arbitrary ranges of latitude. Divided in this way the quantity of data is rather small, and it is evident that the middle temperature can vary considerably in any one month and latitude, but it is obvious from the average figures that it generally falls to a minimum about September and October, and rises to a maximum about February. This is naturally to be expected since the sea temperature varies with the time of year while the latitude of the convergence is little affected. The figures also leave little doubt that where the convergence is in a high latitude the middle temperature tends to be lower than where it lies in a low latitude, though the difference is not very great. This implies that surface isotherms near the convergence do not always run quite parallel to it.

Table 4. *The observed middle temperatures of the convergence gradient for month and latitude*

	North of 50° S				50°–54° S				54°–58° S				South of 58° S			
	Mean	No.	Max.	Min.	Mean	No.	Max.	Min.	Mean	No.	Max.	Min.	Mean	No.	Max.	Min.
September	2·25	2	2·50	2·00	—	—	—	—	2·82	3	3·75	2·00	1·75	2	2·00	1·50
October	2·63	3	4·00	1·70	2·21	5	3·25	1·65	—	—	—	—	1·32	2	1·35	1·30
November	3·63	5	4·10	2·85	3·43	3	3·63	3·15	2·59	4	3·10	2·15	2·38	3	3·00	2·00
December	4·04	4	4·50	3·50	3·57	6	4·20	3·20	2·76	3	3·20	2·00	2·55	1	—	—
January	—	—	—	—	4·20	2	4·40	4·00	4·50	1	—	—	4·50	1	—	—
February	5·18	4	5·30	4·90	4·37	3	4·50	4·10	5·17	3	5·51	4·50	4·47	4	5·89	4·00
March	4·64	4	5·15	4·00	5·23	3	5·80	4·40	4·30	4	4·75	4·10	3·50	1	—	—
April	4·61	4	5·30	4·25	4·25	3	4·50	3·80	3·79	2	4·08	3·50	4·15	2	4·90	3·40
May	4·33	2	5·85	2·81	3·45	3	4·45	2·80	3·60	1	—	—	—	—	—	—
June	2·95	1	—	—	—	—	—	—	3·72	2	4·00	3·45	—	—	—	—
July	4·05	1	—	—	3·50	1	—	—	—	—	—	—	—	—	—	—
August	2·99	4	3·40	2·50	2·00	1	—	—	—	—	—	—	—	—	—	—

It is evident that the average figures can be improved by some method of smoothing, even though the data are insufficient for an accurate estimate of the true averages for each month and latitude. I have therefore adopted the rough and ready method of plotting the averages and drawing curves by eye to make as good a fit as possible. Figures showing the average for all latitudes in different months, and for all months in different latitudes might be misleading, for there are insufficient winter observations in the higher latitudes. In Fig. 6 A–D therefore the monthly averages are plotted separately for each range of latitude and the curves are drawn both to represent the monthly trend of the points, and to resemble each other, for it is assumed that the rate of change does not differ very much in different latitudes. In Fig. 6 E the four curves are shown on the same scale and are marked with the middle latitude of each range. Thus the second curve applies to all records between 50 and 54° S and can be taken to represent 52° S. It will not be far wrong to say that those north of 50° represent 48° S and those south of 58° represent 60° S.

Table 5. *Provisional estimate of the average middle temperature of the convergence gradient in different months and latitudes (figures smoothed)*

	46° S	48° S	50° S	52° S	54° S	56° S	58° S	60° S	62° S	Average
September	2·6	2·5	2·4	2·3	2·1	2·0	1·9	1·8	1·7	2·1
October	2·6	2·5	2·3	2·2	2·1	2·0	1·8	1·7	1·6	2·1
November	3·9	3·6	3·4	3·2	3·0	2·8	2·5	2·3	2·1	3·0
December	4·3	4·1	3·9	3·7	3·4	3·2	3·0	2·8	2·5	3·4
January	5·0	4·9	4·7	4·6	4·5	4·4	4·3	4·2	4·1	4·5
February	5·4	5·2	5·0	4·9	4·8	4·7	4·5	4·4	4·3	4·8
March	5·1	5·0	4·8	4·7	4·6	4·5	4·4	4·3	4·2	4·6
April	4·6	4·5	4·4	4·3	4·2	4·1	4·0	3·9	3·8	4·2
May	4·2	4·1	4·0	3·9	3·7	3·6	3·5	3·4	3·3	3·7
June	3·9	3·8	3·7	3·6	3·5	3·4	3·3	3·2	3·1	3·5
July	3·6	3·5	3·4	3·3	3·2	3·1	3·0	2·9	2·8	3·2
August	3·2	3·1	3·0	2·9	2·8	2·7	2·6	2·5	2·4	2·8
Average	4·0	3·9	3·8	3·7	3·5	3·4	3·2	3·1	3·0	3·5

Table 5 is derived from Fig. 6, and it includes figures for interpolated latitudes and a slight extrapolation to 46 and 62° S. The steps leading up to this table have been explained in detail so as to give some idea of the extent to which it can be relied on. This can be judged from Fig. 6 A–D and the

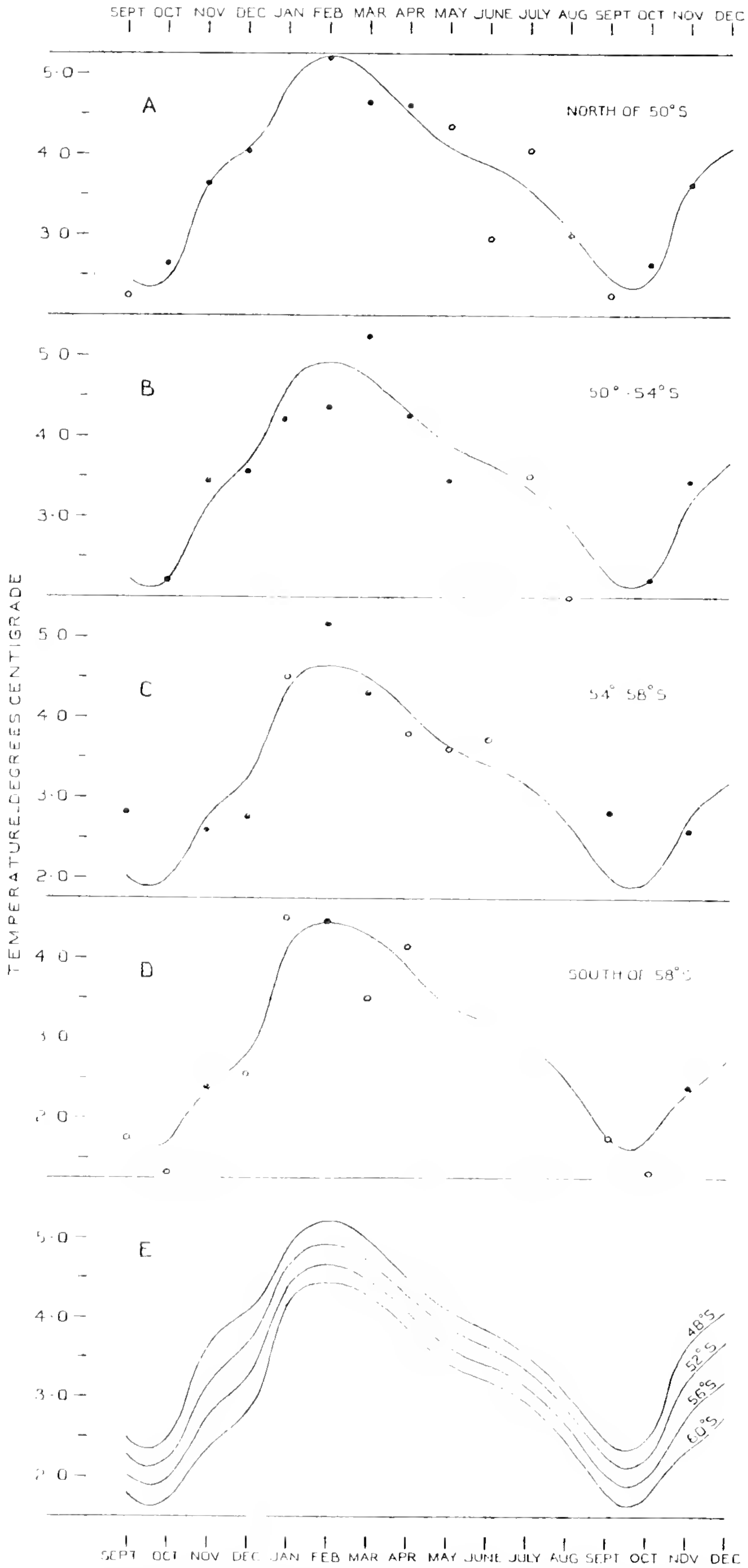

Fig. 6 A–E. Variations of the middle temperature of the convergence gradient. Averages from Table 4 are shown as black dots when based on three or more records, and as rings when based on one or two. The curves in Figs. A–D are reproduced on one temperature scale in Fig. E.

columns in Table 4 headed 'No.' (number of observations). A larger body of data would no doubt result in corrections to most of the figures, but there are two purposes for which the table should be useful. First it is helpful in drawing the charts of surface temperatures with which the latter part of this paper is concerned, and secondly it should sometimes make it easier in the future to locate the convergence. For instance, there is sometimes more than one sharp change of temperature in the neighbourhood of the convergence and the figure given above under the appropriate month and latitude may help to show which actually represents the convergence.

Fig. 6 shows a rapid increase of temperature from October to February, though the increase is slightly retarded from November to December. Although the curves are drawn tentatively there is evidence for this check between November and December. It can be seen in each set of plotted points in Fig. 6, and the averages for these two months are based on more data than most other months. Before their work was interrupted by the war Mr A. J. Clowes and the late Mr J. A. Nicholson made a calculation of the seasonal rise and fall of temperature in part of the Antarctic surface layer by statistical treatment of the vertical temperature readings at a number of stations made by the 'Discovery II' on the Greenwich meridian, and the curve so obtained showed a similar reduction in the rate of increase of temperature. This work was not published, but they suggested that the reduction might be a latent heat effect resulting from the melting of ice.

Table 5 further indicates that the middle temperature varies through an average annual range of about 2·7° C, and by about 1·0° C for 16° of latitude. The actual highest and lowest middle temperatures were 5·89° (No. 15, Feb., 58° S) and 1·30° (No. 86, Oct., 62° S). Table 6 is a comparison of actual middle temperatures with the expected temperatures given in Table 5.

Table 6. *Deviation of observed temperatures from smoothed average middle temperatures of the convergence*

Degrees above or below average temperature	Number of instances	Percentage
0·00–0·49	62	59
0·50–0·99	33	32
1·00–1·49	5	5
1·50–1·99	3	3
2·00–2·49	1	1
2·50–2·99	0	0
	104	100

When the convergence lies north of its normal position the middle temperature is usually (though not always) a little higher than the average, and vice versa. This suggests that variations in the position of the convergence are not dependent on variations of the sea temperature.

It is not certain that Table 5 is equally applicable to all longitudes. There are insufficient data from many parts of the Southern Ocean to test this, but there seems to be no reason why the middle temperature should vary in different longitudes.

When the convergence is crossed the amount of change of temperature at the surface, called here the 'range', may be as much as 4·0° (No. 54, 162° E) or may be so small as to be indistinguishable from other minor fluctuations of temperature (e.g. No. 138 in 01° E). A typical well-defined convergence is seen in Fig. 5 B (p. 187), and here the range is taken as from 1·5 to 3·5, i.e. 2·0° C. The range varies mainly according to longitude; that is to say, it is generally distinctly greater in some regions of the Southern Ocean, than in others. There seems to be no regular variation in the range at different times of year; it does not seem to be affected when the middle temperature of the convergence is higher or lower than the relevant average figure in Table 5; nor does it appear to vary according to the latitude of the convergence in its mean position; but there is almost certainly a tendency for the range to increase a little if the convergence is displaced to the north or south of its mean position. This effect is not obvious, for it is obscured by the more important regional variation, and more data would be needed before it could be measured.

For measurement of the regional variation the average range is plotted in Fig. 7 in convenient groups of longitude, usually between meridians 10° apart. Thus between 20 and 30° W there were five crossings with an average range of 2·4° C; between 5° E and 5° W there were ten with an average range of 1° C. Here again a curve is drawn to mark the trend of the plotted points. The data for this curve are rather uneven. It is well supported in the Atlantic region, but in the Indian Ocean there is not very much to rely on, and in the Pacific sector, between 100 and 160° W, the curve is little better than guesswork. The reason for these variations in the range of the convergence gradient is not quite certain and will need some further investigation.

For the purpose of placing the isotherms about the line of the convergence in Plates II–XII, I have found it convenient to take the range of the gradient at every 10° of longitude from the curve in Fig. 7. The resulting figures are shown in Table 7, which gives an overall average range of 1·7° C.

From Plate I and Tables 5 and 7 it is now easy to estimate the expected position of the convergence and change of temperature at the surface, so far as the available data suggest. For example a ship steaming south in 20° E in December would expect to meet the convergence anywhere within about 50 miles north and 50 miles south of 48° 20′ S (see Table 1 and Plate I). Table 5 gives the middle temperature of the gradient as 4·1° and Table 7 gives the range as 1·4°. We should therefore expect the temperature to fall from 4·8 to 3·4° C. The chances of the gradient being warmer or colder than this can be judged from Table 6, but the chances of finding a larger or smaller range are more difficult to assess.

Table 7. *Provisional estimate of the average range of the convergence gradient in different longitudes*

180° W	1·0° C	60° W	2·6° C	60° E	0·9° C
170 W	1·0	50 W	1·8	70 E	0·9
160 W	1·7	40 W	1·9	80 E	0·9
150 W	2·4	30 W	2·3	90 E	1·0
140 W	2·4	20 W	2·3	100 E	1·0
130 W	2·1	10 W	1·7	110 E	1·1
120 W	1·7	0	1·0	120 E	1·6
110 W	1·7	10 E	0·8	130 E	2·0
100 W	2·0	20 E	1·4	140 E	2·4
90 W	2·0	30 E	2·1	150 E	2·8
80 W	1·8	40 E	2·2	160 E	2·8
70 W	1·9	50 E	1·3	170 E	2·3

It is to be hoped that further data will be collected in the future, especially in the winter, and from the Indian Ocean and Pacific sectors. It is desirable, for example, that Tables 5 and 7 should be recalculated from fuller material, and much useful information might be obtained if the line of the convergence at the surface could be followed and mapped out for considerable distances.

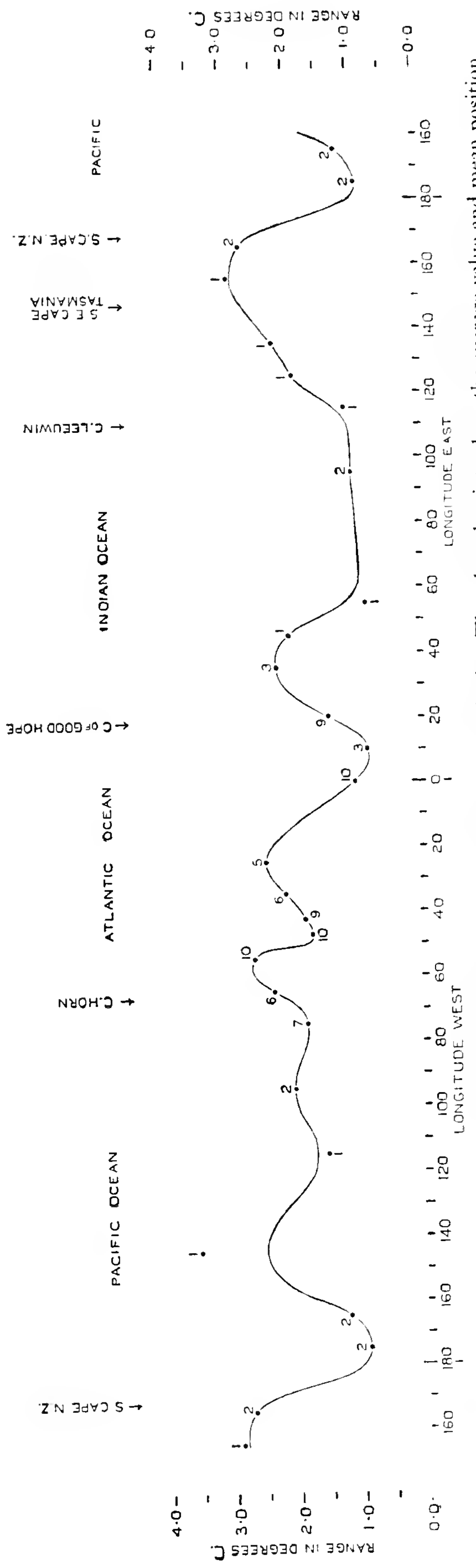

Fig. 7. Variations of the average range of the convergence gradient in different longitudes. The plotted points show the average value and mean position of adjacent records, and numbers show the number of records included.

PART II. THE DISTRIBUTION OF SURFACE TEMPERATURE IN ANTARCTIC WATERS

INTRODUCTION

In 1940 I published, in collaboration with Mr H. F. P. Herdman, a paper on the distribution of the pack-ice, which consisted essentially of a series of charts showing the observed or estimated latitude of the ice-edge in each month in all parts of the Southern Ocean. The present paper is the next step in mapping the surface conditions in Antarctic waters, and its object is to estimate, as nearly as the data allow, the mean positions in each month of the surface isotherms between the ice-edge and the Antarctic convergence.

During the cruises of the 'Discovery', 'Discovery II' and 'William Scoresby' between 1926 and 1939 a very large quantity of data on surface temperatures has been collected. These data of course include far more than the surface temperatures published in the Station Lists (*Discovery Reports*, vols. I, III, IV, XXI, XXII, XXIV). It is the thermograph carried in these ships which furnishes the most important body of data, for this instrument was in continuous use (except for one short period) throughout the voyages of the 'Discovery' and 'Discovery II', and in the last commission (1937–8) of the 'William Scoresby'.

The data are unfortunately distributed very unevenly in time and space, for the movements of the ships were generally dictated by other considerations than covering the surface as equally as possible. Plates II–XII show (in yellow) where observations were obtained in each month, and it will be seen that although the Atlantic sector is well covered at nearly all times of year there are large gaps in other sectors, especially in the winter months.

Some data on surface temperatures south of the Antarctic convergence are of course available from other sources. These are the observations made by other Antarctic expeditions and some published observations made by whaling factories. I have not, however, obtained very much assistance from this material. A large number of the observations were made within the pack-ice or near its fringe, and it is not certain whether some of the others are sufficiently accurate (see pp. 197–8). The number of reliable records from all other sources of temperature in the open regions of the Antarctic surface water are very small compared with the Discovery Committee's material, and they cover few of the gaps mentioned above.

Since the surface temperature in any given locality depends primarily on the time of year, I have set out to plot all appropriate records on separate charts for each month, irrespective of the year in which they were made. In some years of course the temperature at a given place in any one month is above or below the average, but these irregular annual variations seem to have only a local and temporary significance, and their range is much less than that of the regular seasonal rise and fall of temperature. The charts used were semicircular overlapping charts identical with those used for plotting the ice-edge (Mackintosh and Herdman, 1940). The isotherms were then drawn to fit the actual observations as nearly as possible. Some adjustments were made after a comparison of the monthly position of each isotherm, and in areas where no observations were available in certain months, tentative isotherms were filled in by interpolation as described below. Finally, the isotherms were transferred to the circumpolar charts reproduced here in Plates II–XII. The various steps in the treatment of the data are described below in some detail because they raise certain points in technique which seem worth recording.

TREATMENT OF THE DATA

As mentioned above, the continuous thermograph provides the most important body of data. In this instrument the thermometer bulb lies in a pocket in the ship's hull about 14 ft. below the surface, and the temperature at that depth is recorded on a chart (see Fig. 5, p. 187) attached to a clockwork drum in the laboratory on deck. Each chart covers a week. The instrument has given very satisfactory results and, provided certain checks are made, the temperature can be read correctly to within less than 0·2° C, and the time to within less than half an hour. Certain possible sources of error have to be considered. The clock has generally been found to keep excellent time, but allowance had occasionally to be made if the drum had not been accurately set when the new chart was attached. The timing could generally be checked at points where the ship was stopped on station, for here the temperature is often traced as a steady horizontal line which is usually distinguishable from the numerous small fluctuations of temperature which appear while the ship is moving (for example, see Fig. 5 A, p. 187, St. 451). The time when the ship is stopped can of course be checked from the logs. Correction of the temperature is more important as there is frequently a slight error which is possibly due to a small amount of play on the arm of the pen. This error seldom exceeds 0·5° C and is usually constant until the chart is replaced, unless substantial changes of temperature occur. The thermograph record should, however, always be checked against direct thermometer readings, preferably with the Nansen-Pettersson water-bottle. Since the 'Discovery' and 'Discovery II' normally worked full stations at frequent intervals, there were few thermograph charts which could not be checked in this way at several points, but it is very evident that the method of reading the temperature in a bucketful of water drawn over the ship's side is wholly unreliable as a check, however carefully the thermometer is read. Such readings seem nearly always to be too high and the error may amount to 1·0° C or more. This method has been criticized elsewhere (see Lumby, 1928).

A further question which arises is whether the thermograph, recording at a depth of 14 ft., properly shows the 'surface' temperature, and whether thermometer readings at 0 m. constitute a valid check. In other words, what difference may there be in Antarctic waters between the temperature at 0 m. and about 5 m.? At full stations the vertical series of temperatures, etc., included readings at 0 and 10 m., and I have worked through the station lists and assembled the data on this point in Table 8. This includes 987 vertical stations at which the temperature at 0 m. did not exceed 5·0° C (i.e. the vast majority of stations south of the Antarctic convergence) and it will be seen that, except in the summer months (December–February) about 90% showed less than 0·1° C difference between 0 and 10 m. Even in the summer months when occasional superficial sun-warmed patches may be expected, any significant difference is rare, and the difference between 0 and 5 m. must be still less. There have been one or two occasions when a vertical station has been worked in the vicinity of an iceberg, and where a cold, less saline, surface stratum has depressed the temperature at 0 m. below that at 10 m. In any case where there is a significant difference between 0 and 10 m. it is preferable to check the thermograph chart from other stations.

Since ship's time changes with changing longitude the clocks are frequently changed at sea, often several times in a week. The thermograph cannot conveniently be adjusted to ship's time and is therefore set at G.M.T. But the temperature readings must be linked with the ship's position, the stations, and other observations, all of which are recorded by ship's time. It is therefore desirable to mark a scale of ship's time on the thermograph charts. I found it best to trace the corrected temperature on to new charts, marked with the ship's time scale, periods on station, and other annotations.

The next step was to draw track charts, marked with ship's time, for all voyages south of 45° S except such complex local movements as were undertaken in the oceanographic surveys around South

Georgia and in the Bransfield Strait. The tracks were plotted on the usual semicircular charts. The scale was 6 mm. to a degree of latitude, and it was thus possible to mark the ship's hourly positions by dots at intervals of a millimetre or less (1 mm. = 10 miles). The ship's positions recorded in the logs, usually at 4–8 hr. intervals, were plotted first and the hourly positions interpolated. Such plotting of the ships' tracks over many thousands of miles was naturally very laborious, but the resulting charts should in due course facilitate the plotting of various observations in addition to surface temperatures. A small part of one of these charts is reproduced on the original scale in Fig. 8 A. These track charts were then compared with the thermograph charts and the ship's track was marked in pencil at each point at which the temperature line crossed the line of a whole or half degree C (−0·5, 0, 0·5, 1·0°, etc.). The lines of the ships' tracks, together with the temperatures were then traced on to monthly temperature charts, all data for any one month being included on one chart or set of overlapping charts, irrespective of the year. The year was, however, marked against each track. A comparison of Figs. 5 and 8 will show the method of plotting. For example, in Fig. 5 A (p. 187) the thermograph record crosses the 3° level at noon on 14 October 1930. The position of this point is found in Fig. 8 A just north of 50° S, and hence 3° is marked in the corresponding position on the ship's track in Fig. 8 B.

Table 8. *Frequency of differences between the temperature at 0 m. and at 10 m. (including all records where the temperature at 0 m. does not exceed 5° C)*

Range of difference (° C)	September, October, November		December, January, February		March, April, May		June, July, August	
	No.	%	No.	%	No.	%	No.	%
0·00–0·09	239	89·8	368	77·3	196	91·2	27	90·0
0·10–0·19	22	8·3	46	9·7	11	5·1	2	6·7
0·20–0·29	3	1·1	26	5·5	5	2·3	—	—
0·30–0·39	—	—	12	2·6	2	0·9	1	3·3
0·40–0·49	1	0·4	6	1·2	—	—	—	—
0·50–0·59	—	—	8	1·7	—	—	—	—
0·60–0·69	—	—	3	0·6	—	—	—	—
0·70–0·79	1	0·4	—	—	1	0·5	—	—
0·80–0·89	—	—	1	0·2	—	—	—	—
0·90–0·99	—	—	2	0·4	—	—	—	—
1·00–1·09	—	—	1	0·2	—	—	—	—
1·10–1·19	—	—	—	—	—	—	—	—
1·20–1·29	—	—	1	0·2	—	—	—	—
1·30–1·39	—	—	—	—	—	—	—	—
1·40–1·49	—	—	2	0·4	—	—	—	—
	266	100	476	100	215	100	30	100

A large number of temperature records at single positions were then added to the temperature charts. These included the surface temperatures read at stations made by the Discovery Committee's ships when no thermograph chart was available (mainly derived from the 'William Scoresby'), and published records from other sources.

Part of a chart of October temperatures is reproduced as an example in Fig. 8 B. The mean isotherms indicated here are in their final position, as shown in Plate II, after comparison with the corresponding isotherms of other months. They represent the temperatures for both September and October, which are very similar; but there is not room to show the observed temperatures for September on the same chart, for in places the ship's tracks for the two months almost coincide. It should be mentioned that the mean isotherms cannot always be made to correspond with the observed temperatures so well as they do in this chart.

Of the published records from other sources, perhaps the most important are those in the Meteor Reports (Böhnecke, 1936). Here a very large number of surface temperature readings are tabulated, but they are from all parts of the Atlantic Ocean and only a small percentage lie south of the Antarctic convergence. Böhnecke gives two principal tables. One shows the temperatures (also $S^{\circ}/_{\circ\circ}$, etc.) recorded by the 'Meteor', with date and position (pp. 41–64). Only a small number of these are in Antarctic water, but they are of some assistance although they fill no important gaps in the Discovery material. For the other table (pp. 65–186) the Atlantic Ocean is divided into areas enclosed by 10° of latitude and longitude, and these are subdivided into 1° areas. Data from many sources are included and, so far as the data permit, the average temperature is given for each 1° area for each month. Some of these are in Antarctic waters, but it seems that such averages, compiled from miscellaneous sources, should be treated with caution. Böhnecke drew charts of the Atlantic Ocean showing the surface

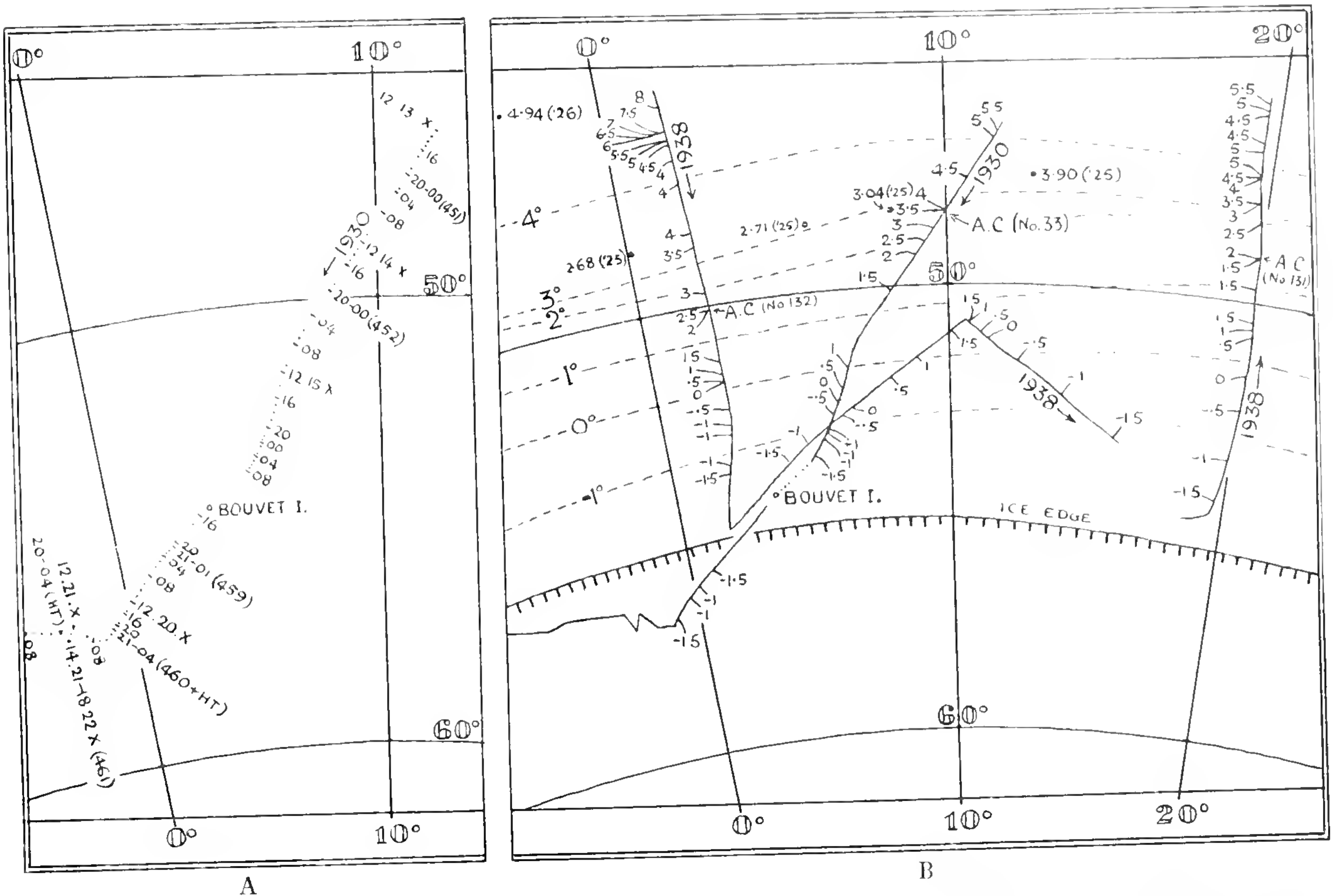

Fig. 8. A. Part of a track chart for October 1930, showing hourly positions of the 'Discovery II' during a voyage from Cape Town to South Georgia. See Fig. 5 A for the thermograph record of part of this track.

12. 13. x: Ship's position at 1200 hours on 13th October.
20–00 (451): Stopped on Station 451 from c. 2000 to 0000 hours.
HT: Hove to.

B. Part of a temperature chart for October, including the track in A with data from other years added, showing observed temperatures and mean isotherms. Continuous lines are the ship's tracks with temperatures from thermograph records. Dots show the positions of isolated observations. Pecked lines are the mean isotherms for September and October reproduced from Plate II, and the 2° isotherm lies on the mean position of the convergence.

A.C. (No. 33): Observed position of the Antarctic convergence (No. 33 in Table 9, p. 206).
('25): Meteor observations, 1925.
('26): 'William Scoresby' station, 1926.

isotherms for each month (bound separately in an 'Atlas'), and although these no doubt give a correct picture of the general distribution of Atlantic surface temperature, some features of the isotherms south of about 50° S (e.g. 0 and −1° in March) are certainly not compatible with the Discovery data. In his later paper (1938) Böhnecke gives a table of surface temperatures in 2° squares.

The Norwegian Meteorological Institute published a series of records (1935) collected by whaling factories for the International Polar Year, 1932–3. These include readings of sea temperature which are no doubt accurate, but the great majority were taken near the ice-edge and for our present purpose do little more than confirm that temperatures here are about or below −1° C. Some temperatures recorded in the first part of the homeward voyages, however, are helpful, though these again do not fill any important gaps. A limited number of observations between the ice-edge and the convergence are to be found also in results of the 'Norvegia' expeditions (see Mosby, 1933, 1934).

The Australasian expeditions under Sir Douglas Mawson provide material in the Australian Sector in some months in which the Discovery Committee's ships collected no data in that region. Some of the temperatures recorded in the earlier expedition (1911–14) seem very high, and here again it is difficult to know whether they are fully reliable; but those recorded in the Station List of the B.A.N.Z.A.R. Expedition of 1929–31 are undoubtedly reliable (see Mawson, 1940; and Johnson, 1937).

METHOD OF DRAWING THE ISOTHERMS

The distribution of surface temperature is of course subject not only to annual variations, but also to innumerable local and temporary variations and complexities. The object here is to draw isotherms to show as nearly as possible the average distribution of temperature for each month. Thus Plates II–XII show the temperatures which would *probably* be found in certain positions at different times of year. For example, in January the 2° isotherm crosses longitude 30° W in 53° 30′ S. This means that according to past experience a ship arriving at that position about the middle of January is more likely to find that sea temperature than any other. If a higher or lower temperature is found it is probable, but not certain, that in that region the surface water is warmer or colder than usual, and the degree of probability will depend mainly on the number of different years from which data near to that position are available. Data from the preceding and succeeding months will be relevant as well as from the month in question.

Since in some regions data are lacking, and in some other regions insufficient to indicate the extent of annual variations, Plates II–XII can only be a first approximation to the average distribution of temperature. The data are, however, very extensive, and the charts should give a more correct view of the distribution of temperature in these waters than any that have been published before.

It is obvious that the basic pattern of the isotherms must be a system of concentric rings, generally representing a falling gradient from north to south. The rings, however, are distorted in various ways by water movements and the configuration of the land and the sea floor. The gradient is not usually a steady one, but apart from small fluctuations it is not often inverted on a substantial scale. Inspection of the temperature charts[1] indicates that the highest temperatures generally prevail in February, and suggests that the lowest occur about September and October (see also Fig. 6, p. 190). In drawing the isotherm charts I have assumed that any isotherm should be placed progressively farther south in each month from October to February, and similarly farther north from February to September. A break in the average seasonal rise and fall of temperature is not perhaps impossible, but the assumption that there is no such break seems justified in the absence of evidence to the contrary. There are

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[1] The term 'temperature chart' is used for the original charts on which the actual temperatures were plotted. Plates II–XII are referred to as isotherm charts.

comparatively few records for July and August, but these months are evidently not much warmer than September.

Before any isotherms were drawn the Antarctic convergence was drawn in its mean position on each of the temperature charts, and the mean position of the pack-ice edge for the month in question was added. The latter was traced from the original charts reproduced in the report on the pack-ice (Mackintosh and Herdman, 1940, plates lxxi–xcv), and no alterations were made except for one small adjustment. Inspection of the sea temperatures in the Falkland sector in November and re-examination of the ice records suggested that the mean position of the ice-edge here should be drawn a little farther south. Accordingly the line of the ice-edge in November between 10 and 70° W has been moved about 20–40 miles farther south.

The lines of the ice-edge and the convergence form very useful starting points in the drawing of the isotherms. The line of the ice-edge can be taken as coinciding approximately with the isotherm of −1·5° C. (It does not of course always coincide for the sea temperature at the ice-edge is sometimes above −1° in summer or below −1·5° in winter, but some allowance can be made for this.) From Tables 5 and 7 (pp. 189 and 192) we can calculate which isotherms should lie on the line of the convergence. If these steps are accepted then the intermediate isotherms must lie at intervals within a limited belt.

The isotherms are drawn at intervals of 1° C, and in the first place were sketched in pencil on the temperature charts. Those falling on the convergence were entered first, and they were derived from Tables 5 and 7. For example, in April in 60° W (see Plate VIII) the middle temperature by Table 5 is 4·0° and the range by Table 7 is 2·6°. This gives a gradient from 2·7 to 5·3° which includes the isotherms of 3, 4 and 5°. In 50° W, however, the gradient is from 3·2 to 5·0° which includes only the 4° and 5° isotherms. The 3° isotherm must therefore diverge away from the line of the convergence between 60 and 50° W. In this way the isotherms were drawn along the whole length of the convergence for each month.[1] At some points (e.g. 10° E) the average range of the gradient is less than 1° C and the line of the convergence cannot accommodate more than one isotherm. Elsewhere the convergence can be distinguished by the concentration of two or more isotherms.

The isotherms between the ice-edge and the convergence, and one or two also in sub-Antarctic water north of the convergence, were then sketched in on the temperature charts. With data from several different years included in a chart for one month, it was at once obvious that any attempt to join all points of a given observed temperature would lead to absurdities. However, such points of equal temperature were connected as often as possible provided this did not involve any improbable deviation from the general trend of the adjacent isotherms and of the lines of the ice-edge and convergence. If in any locality observations were available from only one year it was assumed that they represented average conditions, unless observations from that and other years in adjacent regions indicated any departure from the average. Where observations from different years suggested different latitudes for the isotherm the line was drawn as nearly as possible in the mean position. At many points of course it was difficult to decide where to place an isotherm, and even where observations were plentiful the isotherms could be drawn with much more confidence at some points than at others. However, they were drawn so as to make as good a fit as possible with the observed temperatures. Fig. 8 B (p. 197) is an example of a fairly good fit. In this area the October temperatures for 1930 and 1938 corresponded almost exactly. In 1925 and 1926 in October and in 1936 in September the water was a little colder, at least in the northern part of the area. September and October temperatures in 1938 were very similar.

Whereas the majority of isotherms were in this way drawn by eye on the charts of observed

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[1] But see below with regard to special adjustments at one or two points.

temperatures, the isotherms on the line of the convergence were derived from Tables 5 and 7. Although both are dependent for the most part on the same body of data this might have resulted in some inconsistencies, for Table 5 is no more than approximately correct, and as noted on p. 191 it is not certain that it is equally applicable to all longitudes. Furthermore, the position of the isotherms not on the convergence are in places influenced by extraneous data. However, the relative positions of isotherms on the convergence and of those to the south of it were generally found to be quite consistent, and only at one or two points was a compromise necessary. Thus in 150–170° E the 2° isotherm in December and the 3° isotherm in January are placed a little south of the convergence, although they should just be on it according to Tables 5 and 7, and a similar adjustment has been made in 60° W in January.

Tentative isotherms were thus drawn for all months and for all regions except for the major areas in which observations were lacking, and the next step was to compare single isotherms month by month. For this purpose the isotherms of one temperature, for example all the 0° isotherms, for each of the months October to February (i.e. coldest to warmest months) were traced on to one chart, as in Plate XIII. It is to be supposed that during the whole of this period the sea temperature is on the average rising, and that therefore the 0° isotherm (or any other) will lie farther south in each successive month. This was found to be so, the 0° isotherms forming a succession of concentric rings which did not touch or intersect each other except at one or two points. Such instances were assumed to be due to abnormal conditions or annual variations, and the positions of the isotherms were adjusted accordingly. For example, it was found at one point that the November isotherm, depending mainly on temperatures in 1926, ran for a short distance a little north of the October isotherm which depended on temperatures in 1936. Further inspection of the temperature charts indicated that in an adjacent region the spring temperatures in 1926 were rather lower than in several other years. Therefore where the overlap occurred the November isotherm was adjusted so as to lie a little south of the October isotherm. The fact that such adjustments were few, and involved only small changes in the position of the isotherms, suggested that they had been drawn not far from the correct positions. Some other adjustments were made so that isotherms of adjacent months should be approximately parallel and show similar features; but this was only done where it involved small alterations which were not too inconsistent with the observed temperatures. Sometimes the form of an isotherm changes considerably from one month to the next (cf. the 0° isotherms for December and January between 30° W and 30° E, Plate XIII).

One isotherm having been adjusted in this way, it was traced back in its new form on to the temperature charts and the process was repeated for the other isotherms for September–February, and then for all isotherms for February–September (the period of falling temperatures). It amounts of course to a means of supplementing the data for one month with the data for other months on the assumption that there is an unbroken rise of temperature from October to February and an unbroken fall from February to September (see p. 198).

The revised isotherms were checked against the temperature charts in case of any unjustified departures from the observed temperatures, and were then transferred from the original semicircular charts to the circumpolar charts of a rather smaller scale which are reproduced in Plates II–XII. It remained to fill in the isotherms in the regions in which no observations had been made (mainly in the winter months). These were sketched on the circumpolar charts in what appeared to be the probable positions by analogy with the isotherms already drawn. Each isotherm was then traced as before on to a separate chart, adjusted with the same isotherms for other months, and traced back again. These isotherms are shown as pecked lines in Plates II–XII. Often it was a matter of simple interpolation. For example, between 80 and 110° W the 0° isotherms for November and January are based on observed temperatures, but there were no data here for December. The December isotherm, however, must lie between those for November and January, and since the observed temperatures nearly everywhere indicate that it lies nearer to the November than to the January isotherm there was no difficulty in deciding where to draw it here (see Plate IV). A good interpolation of this kind may sometimes give a more reliable position for the isotherm than a limited set of direct observations. Farther west the November and December isotherms are both interpolated between those for October and January, and in the winter months in the Pacific sector the 0° isotherms for five or six consecutive months have to be interpolated (see Plate XIV). Here of course there is less certainty, especially as the September isotherm rests on observations only from one year (1932). Even so there is not very much choice in the positions in which they might be drawn.

NOTES ON THE DISTRIBUTION OF TEMPERATURE

It will be realized that Plates II–XII are semidiagrammatic charts which represent only the major features of temperature distribution. Surface temperatures are naturally subject to some appreciable widespread variations and to more numerous local variations; and if the isotherms could be drawn in full detail for any area at a given time they would usually reveal elaborate complexities, and bear little resemblance to the smooth lines in Plates II–XII. Fig. 9 shows the apparent actual distribution of temperature between South Georgia and the Falkland Islands in September and October 1934, and may be compared with Fig. 1 (p. 182) and with the corresponding region in Plate II. The isotherms are correctly placed where they cross the ship's tracks, and between these tracks they are drawn in what seem to be the most probable positions; but there is not much doubt that, if additional lines of observations could have been made at the same time, a still more complex picture would be presented.

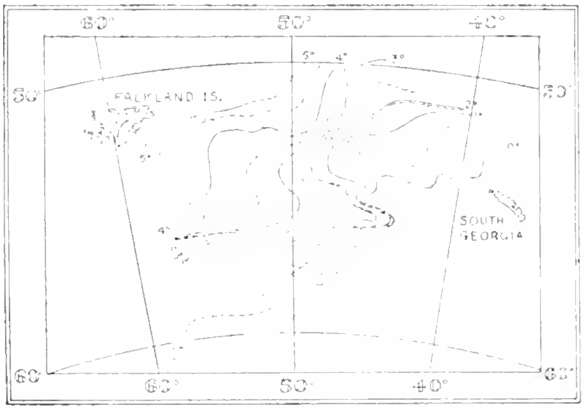

Fig. 9. Observed temperatures in the Scotia Sea, 1st September to 14th October, 1934, showing the apparent positions of the isotherms. Half-degree isotherms are shown as pecked lines, and the ship's tracks as dotted lines.

Most charts of temperature distribution as observed at a particular time would be likely to show some features, such as tongues of warm or cold water and other bends in the isotherms, which are temporary, and which become smoothed out when the isotherms are drawn in their mean positions. Plates II–XII are intended to show only those features which seem to be constant, or which at least are found in most of the years for which observations are available. Even such constant features have been drawn with caution, and it may be that some of them are not sufficiently emphasized.

The following points may be noted. South of the Falkland Islands in about 55° W there is some evidence of a northward thrust of cold water. This is noticeable in the chart for September and October (Plate II) where the isotherms are crowded up to the convergence. For this chart there are data only for one year (see Fig. 9), but the bend in the convergence here and the similar shape of the isotherms in other months suggest that this is a constant feature. It is perhaps more noticeable in spring than in summer. A more conspicuous tongue of cold water projects northwards around the South Sandwich Islands (near 30° W). This is often very pronounced, and it is probably connected with a comparatively narrow thrust of cold water off the north-east side of South Georgia, which was found during intensive observations around the island. Warmer water is found to the east of the South Sandwich Islands, and it is possible that the southward bend of the isotherms about 10–20° W is not sufficiently emphasized in the charts. It is best seen in the charts for March and April, but it is not certain that it is really more conspicuous in these months than at other times of year. It seems probable that further examination of such features as these will show that they are correlated with the effects of bottom topography.

Between about 10° W and 30° E the positions of the isotherms are very much influenced by the eastward flow of cold water from the Weddell Sea, which also has an important effect here on the distribution of pack-ice in the early summer (see Mackintosh and Herdman, 1940, p. 293). In winter and spring the isotherms tend to be pressed up towards the convergence which here lies about its lowest latitude, but in December, while pack-ice and cold water persist in a relatively low latitude between 0 and 30° E, east of 30° both ice-edge and isotherms bend far to the south, and the ice belt begins to break up internally, leaving an outer zone which contracts towards the South Sandwich Islands (compare the ice-edge in Plates IV and V, December and January). As the outer zone of ice melts away it tends to leave a long tongue of cold water which is seen as a conspicuous S-shaped turn in the isotherms in Plates V–VII. The shape of the isotherms here is subject to a good deal of variation. The data indicate that a line of observations running south from the convergence will usually, but not always, reveal a slight rise in temperature about 60–65° S, and if there is no actual rise in temperature, there will at least be a long expanse of ocean in which the temperature at the surface will change very little. The existence of a belt of relatively warm water here, which melts the ice in a high latitude while a zone of pack-ice still persists to the north of it, is noted by Deacon (1937, pp. 18, 28, etc., and Fig. 8), who describes it as an ill-defined divergence region with an upwelling of warm water between the Weddell Sea current moving eastwards in a lower latitude, and the current moving westward in a higher latitude near the continental coast. Deacon also refers (p. 30) to the outer and inner belts of pack-ice, and adds: 'It is just possible that even in winter there may be open water between the two ice-streams in the eastern part of the Atlantic Ocean.'

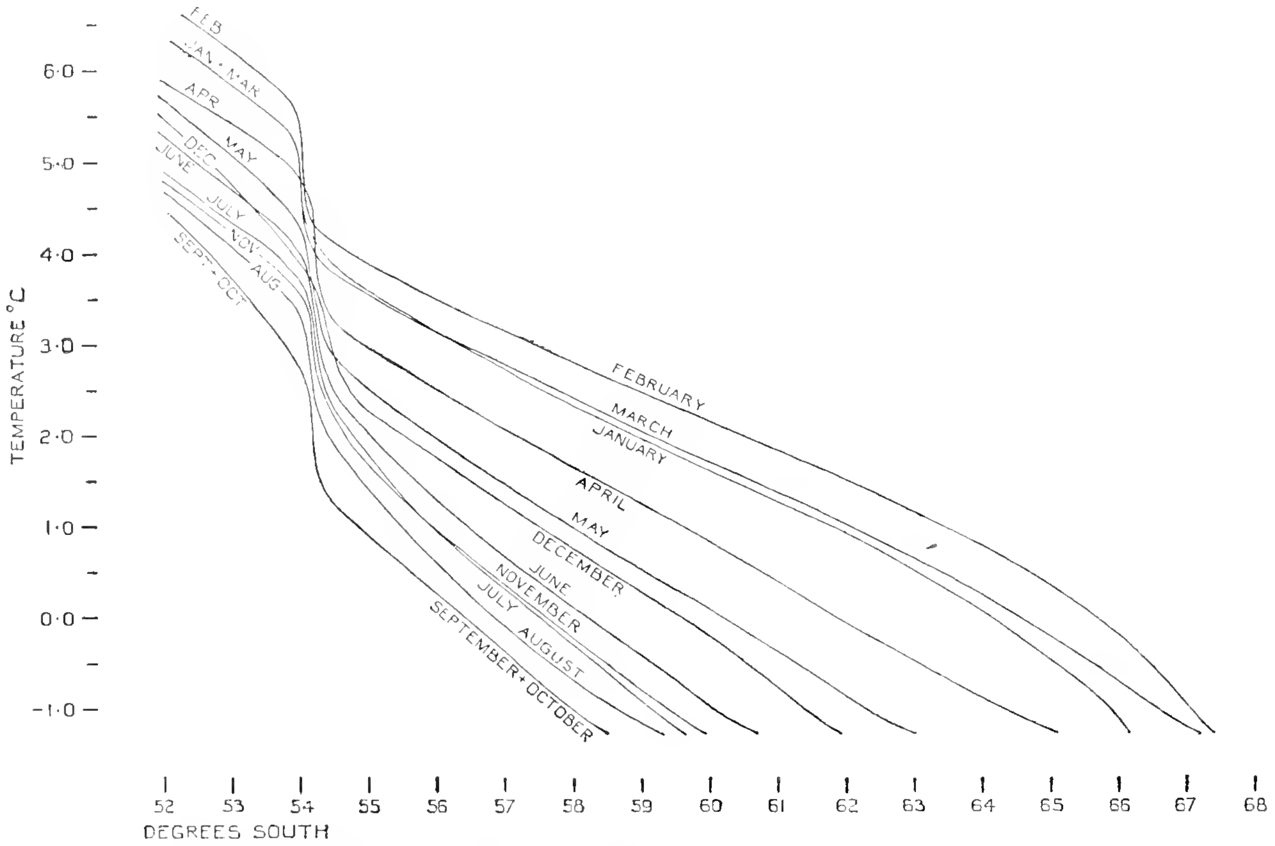

Fig. 10. Comparison of average monthly temperatures, based on monthly isotherms.

Meridional lines of observations in this region in April are only available for one year (1938). No warm belt was then distinguishable, and the isotherms in Plate VIII are drawn accordingly. It is not perhaps certain that the S-shaped bend in the isotherms is normally smoothed out in April, but it may be that the advance of winter conditions has by then obliterated any signs of a warm belt at the surface.

The loop in the convergence in 30° E is referred to on p. 184. It is possible that more of the adjacent isotherms are involved in this disturbance than the charts suggest, but more data would be needed to decide this point.

The course of the isotherms in the Indian Ocean and Australian regions call for no special comment. The charts are self-explanatory, and it will be seen that more data are needed in some months.

The Ross Sea is another locality in which open water is found in a high latitude while pack-ice still lies to the north. The isotherm for $-1°$ should perhaps reappear here in January, February and March, but there is little material to show in what shape it should be drawn, and it is therefore omitted.

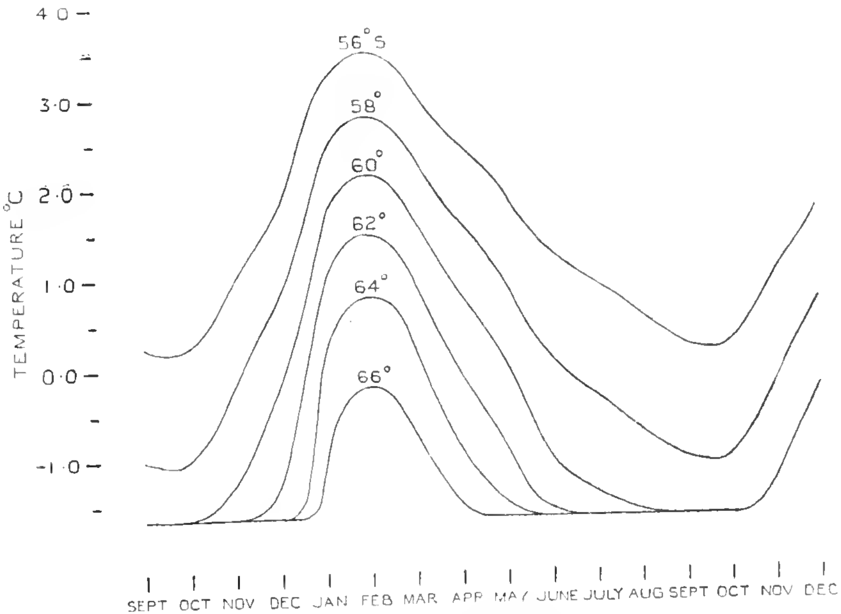

Fig. 11. Seasonal rise and fall of temperature, derived from Fig. 10.

In the Pacific sector the northward extension of cold water between 120 and 160° W, and the compression of the isotherms in the winter and spring months in the Bellingshausen Sea and Drake Strait (60–90° W) are probably permanent features.

It is of some interest to make a graphical comparison of the temperature in different months and different latitudes. For Fig. 10 the latitude of each isotherm in each month was measured in Plates II–XII at every 30° of longitude, and the average was plotted. For example, in Plate VI (February) the average latitude of the 0° isotherm was found to be 65° 40′ S. Thus in Fig. 10 the curve for February crosses 0° C in 65° 40′ S. In so far as the mean isotherms are correct the diagram should give a correct impression of the differences in average temperature between the different months, and of the slope of the temperature gradient south of the convergence. The slope of the gradient on the convergence and to the north of it, and differences in the shapes of the monthly curves are perhaps not very reliable. The figure shows that surface temperatures are much the same in January and March, or in November and July, that south of the convergence the water is warmer in December than in June, etc., but it would probably not be justifiable to infer much more than this.

Fig. 11 is derived from Fig. 10, the temperature for each month being plotted at arbitrary intervals of latitude. The flattening of the curves at the foot of the diagram indicates that the water is (on the average) covered by pack-ice in the months and latitudes in question. The figure suggests that when the sea becomes free of ice in the early summer, the rise in temperature (December–January) is more rapid in high than in low latitudes. Here again, however, the curves can only be taken as a rough indication of the rise and fall of temperature.

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APPENDIX

Table 9. *The Antarctic convergence. List of all occasions on which the convergence has been crossed or located by ships of the Discovery Committee*

Abbreviations:

adj.	adjacent	ship's T.s	Routine 4-hourly temperatures (Fahrenheit) entered in ship's log
approx.	approximate	St.	Station
betw.	between	surf.	surface
D.R.	dead reckoning	temp.	temperature
hr.	hours	W.S.	'William Scoresby'
min.	minimum		

Note. Where the hour is noted in the 'Remarks' column it refers to ship's time on the date in the 'Date' column, and is given mainly to facilitate reference back to the original data.

No.	Ship	Voyage	Date	Estimated position	Degree of accuracy	Remarks
1	'Discovery'	Tristan da Cunha to S. Georgia	14. ii. 26 14. ii. 26 15. ii. 26 15. ii. 26 16. ii. 26 16. ii. 26 16. ii. 26	47° 15′ S, 25° 20′ W 48° 05′ S, 27° 05′ W 49° 10′ S, 28° 35′ W 49° 20′ S, 28° 55′ W 49° 53′ S, 29° 40′ W 50° 10′ S, 30° 00′ W 50° 35′ S, 30° 45′ W	Probable ,, ,, ,, ,, ,, Good	By min. temp. betw. Sts. 10 and 11. By thermograph crossing loops of the convergence at 0800 and 2000 hr. on 14th, 1500 and 1800 hr. on 15th, and 0100, 0400 and 1700 hr. on 16th, the last crossing being the most definite.
2	,,	S. Georgia to Falkland Is.	20. iv. 26	52° 10′ S, 43° 00′ W	Uncertain	No adj. Sts. Thermograph not clear; probably 0200 hr.
3	'W. Scoresby'	Cape Town to S. Georgia	28. x. 26	47° 00′ S, 06° 45′ W	Probable	Betw. Sts. WS 11 and 12. Ship's T.s indicate about 1800 hr.
4	'Discovery'	,,	6. xi. 26	47° 10′ S, 14° 10′ E	Uncertain	No adj. Sts. Thermograph suggests 1800 hr., but doubtful.
5	,,	S. Georgia to S. Orkneys	8. ii. 27	54° 35′ S, 42° 50′ W	Approx.	Thermograph rises to over 4° C at 1600 hr., indicating proximity of a loop of the convergence.
6	'W. Scoresby'	S. Georgia to Falkland Is.	20. ii. 27	53° 19′ S, 45° 40′ W	Good	By min. temp. betw. Sts. WS 67 and 68. By ship's T.s about 1500 hr.
7	'Discovery'	S. Shetlands to C. Horn	18. iv. 27	58° 28′ S, 67° 55′ W	Approx.	By min. temp. about St. 216. By thermograph about St. 217.
8	'W. Scoresby'	Falkland Is. to S. Georgia	13. v. 27	52° 30′ S, 48° 15′ W	Approx.	No. adj. Sts. By ship's T.s about 1800 hr. Position by D.R.
9	,,	S. Georgia to Gough I.	31. v. 27 1. vi. 27 1. vi. 27	49° 12′ S, 35° 50′ W 48° 40′ S, 34° 00′ W 47° 47′ S, 31° 34′ W	Probable Uncertain ,,	No temps. at Sts. Ship's T.s show marked rise about 1800 hr. on 31. v. 27, and indications of loops at about 0200 and 1500 hr. on 1. vi. 27.
10	,,	Falkland Is. to S. Georgia	11. ii. 28	53° 17′ S, 47° 02′ W	Approx.	By min. temp. about St. WS 140. St. showed surf. cooled by nearby ice island and brash ice.
11	,,	S. Orkneys to Falkland Is.	26. iv. 28 27. iv. 28 27. iv. 28	56° 27′ S, 54° 22′ W 56° 24′ S, 54° 30′ W 56° 12′ S, 55° 00′ W	Good Uncertain ,,	By min. temp. about St. WS 204. Ship's T.s show rise at St. WS 204 and indicate loops about 0800 and 1400 hr. on 27. iv. 28.
12	,,	Falkland Is. to S. Georgia	22. viii. 28	52° 50′ S, 47° 40′ W	Good	By min. temp. betw. Sts. WS 253 and 254. By ship's T.s about 0600 hr.
13	,,	S. Georgia to Falkland Is.	4. xii. 28	52° 45′ S, 48° 25′ W	,,	By min. temp. betw. Sts. WS 316 and 317. By ship's T.s about 0200 hr.
14	,,	Falkland Is. to S. Georgia	14. xii. 28	52° 30′ S, 49° 00′ W	,,	No. adj. Sts. Ship's T.s show clear convergence at 1600 hr.
15	,,	S. Shetlands to C. Horn	23. ii. 29	58° 21′ S, 65° 37′ W	,,	By min. temp. betw. Sts. WS 404 and 405. No clear indication by ship's T.s.
16	,,	Falkland Is. to S. Georgia	15/16. iii. 29	?	—	No temps. at Sts. Ship's T.s indeterminate.
17	,,	S. Georgia to Falkland Is.	30. iv. 29	52° 40′ S, 48° 09′ W	Probable	By min. temp. near St. WS 429, but ship's T.s indicate on St. WS 430.
18	,,	Falkland Is. to S. Georgia	7. v. 29	52° 45′ S, 46° 20′ W	Approx.	No. adj. Sts. Ship's T.s show convergence, but D.R. positions doubtful.
19	,,	S. Georgia to Cape Town	19. v. 29 19. v. 29	50° 55′ S, 29° 53′ W 50° 13′ S, 27° 40′ W	Uncertain ,,	By min. temp. betw. Sts. WS 435 and 437. Ship's T.s suggest running parallel to convergence between positions shown (1200–0000 hr.).

Table 9 (*cont.*)

No.	Ship	Voyage	Date	Estimated position	Degree of accuracy	Remarks
20	'W. Scoresby'	Cape Town to S. Georgia	19, 27. x. 29	47° 12′ S, 07° 50′ W 52° 15′ S, 28° 20′ W	Uncertain ,,	No informative Sts. Ship's T.s showing fluctuating temps. betw. positions shown. 1800 hr. on 19. x. 29 to 0200 hr. on 27. x. 29.
21	,,	S. Georgia to Falkland Is.	2. xi. 29	52° 34′ S, 48° 48′ W	,,	No temps. at Sts. Ship's T.s suggest at or near St. WS 466.
22	,,	Falkland Is. to S. Shetlands	11. xi. 29	57° 16′ S, 57° 14′ W	Approx.	By min. temp. betw. Sts. WS 469 and 470. Ship's T.s fluctuating.
23	,,	S. Shetlands to Falkland Is.	9. i. 30	57° 50′ S, 59° 40′ W	,,	No adj. Sts. Ship's T.s clearly indicate 0600 hr., but latitude doubtful.
24	'Discovery II'	Montevideo to S. Georgia	15(?). i. 30	?	—	No adj. Sts. No indication by thermograph.
25	'W. Scoresby'	Falkland Is. to S. Georgia	16. i. 30	52° 45′ S, 44° 35′ W	Probable	No adj. Sts. Ship's T.s suggest 0200 hr.
26	,,	S. Shetlands to Falkland Is.	20. ii. 30	56° 47′ S, 58° 15′ W	Approx.	No adj. Sts. Ship's T.s indicate 0200 hr., but positions not certain.
27	,,	NW'ward in 55° W	3. iv. 30	55° 45′ S, 54° 50′ W	Good	By min. temp. betw. Sts. WS 529 and 530. Ship's T.s indicate 0200 hr.
28	,,	E'ward in Scotia Sea	6. iv. 30	55° 28′ S, 54° 30′ W	Approx.	No adj. Sts. By ship's T.s at 1800 hr. Subsequently probably running parallel to convergence.
29	'Discovery II'	S. Shetlands to C. Horn	14. iv. 30	59° 15′ S, 64° 10′ W	V. good	By min. temp. near St. 384. By thermograph at 2330 hr.
30	,,	C. Horn to S. Georgia	18. iv. 30 18. iv. 30 19. iv. 30	55° 47′ S, 52° 50′ W 55° 40′ S, 51° 00′ W 55° 10′ S, 47° 20′ W	Good ,, ,,	Surf. temps. only at Sts. By thermograph clearly running parallel to convergence and crossing loops at 0830 and 1900 hr. on 18th, and 0530 on 19th. Some additional fluctuations of temp. E of 47° W.
31	'W. Scoresby'	S. Georgia to Rio.	?. v. 30	?	—	No adj. Sts. Ship's T.s indeterminate.
32	'Discovery II'	S. Georgia to Cape Town	13. v. 30	48° 21′ S, 21° 55′ W	V. good	Surf. temps. only at Sts. Sharp rise in temp. at 1800 hr. Temp. rather high for May.
33	,,	Cape Town to Bouvet I.	14. x. 30	48° 20′ S, 10° 00′ E	Good	By min. temp. betw. Sts. 451 and 452. Thermograph shows slight but distinct fall at 0900 hr.
34	'W. Scoresby'	Montevideo to S. Georgia	9. i. 31	50° 26′ S, 41° 24′ W	Approx.	No adj. Sts. Ship's T.s show changes at 0600 and 1800 hr.
35	'Discovery II'	W'ward from S. Georgia	4. iii. 31	54° 05′ S, 46° 00′ W	V. uncertain	Surf. temps. only at Sts. Thermograph indeterminate but probably crossed convergence at 0430 hr.
36	,,	S'ward in Scotia Sea	6. iii. 31	55° 40′ S, 51° 30′ W	,,	By min. temp. near St. 633. Thermograph indeterminate. Crossing possibly at 0500 hr.
37	,,	S. Shetlands to Staten I.	12. iii. 31	58° 00′ S, 60° 10′ W	V. good	By min. temp. betw. Sts. 648 and 649. By thermograph at 1930 hr.
38	,,	Falkland Is. to S. Georgia	24. iii. 31	53° 17′ S, 47° 35′ W	Probable	By min. temp. betw. Sts. 656 and 657. By thermograph at 1200 hr.
39	'W. Scoresby'	S. Georgia to Falkland Is.	13. iv. 31	52° 30′ S, 47° 45′ W	Uncertain	No. adj. Sts. By ship's T.s about 0200 hr.
40	'Discovery II'	N'ward in 30° W	18. iv. 31	49° 50′ S, 29° 55′ W	V. good	By min. temp. N of St. 666. By thermograph at 0900 hr.
41	,,	S'ward in 75° W	20. xi. 31 21. xi. 31 21. xi. 31	59° 47′ S, 75° 05′ W 62° 05′ S, 75° 01′ W 62° 53′ S, 75° 02′ W	Approx. ,, ,,	By min. temp. betw. Sts. 730 and 731. Thermograph indicates confused loops with sharper fluctuations farther S. Times adopted: 1400 hr. on 20th, 1330 and 1930 hr. on 21st.
42	,,	N'ward in 56° W	28. xi. 31	56° 50′ S, 55° 50′ W	V. good	By min. temp. betw. Sts. 745 and 746. By thermograph at 1700 hr.
43	,,	S'ward in 49° W	3. xii. 31 4. xii. 31 4. xii. 31	55° 50′ S, 49° 02′ W 56° 10′ S, 48° 58′ W 56° 30′ S, 48° 56′ W	,, ,, ,,	By min. temp. betw. Sts. 754 and 755. Sharp convergence at 1845 hr. on 3rd, and well-marked loop or patch of sub-Antarctic water at 0100 and 0300 hr. on 4th.

Table 9 (*cont.*)

No.	Ship	Voyage	Date	Estimated position	Degree of accuracy	Remarks
44	'Discovery II'	North of S. Georgia	16. xii. 31	50° 48′ S, 37° 22′ W	Approx.	By min. temp. near St. 776. By thermograph near St. 775.
45	,,	,, ,, ,,	17. xii. 31	49° 40′ S, 37° 15′ W	,,	By min. temp. near St. 776. By thermograph probably about 1800 hr., but some indications of loops in the convergence.
46	,,	S. Georgia to Falkland Is.	10. ii. 32	52° 40′ S, 43° 30′ W	,,	No. adj. Sts. By ship's T.s about 1100 hr.
47	,,	Falkland Is. to S. Georgia	20. ii. 32	52° 50′ S, 43° 15′ W	Good	By min. temp. betw. Sts. 829 and 830. By thermograph at 0600 hr. betw. Sts. 830 and 831, showing surface stratum of sub-Antarctic water drifted east of normal position. Surface position adopted. Cf. No. 46.
48	,,	S. Georgia to Cape Town	25. ii. 32 25. ii. 32 25. ii. 32 25. ii. 32 26. ii. 32	49° 45′ S, 24° 03′ W 49° 25′ S, 23° 00′ W 48° 55′ S, 21° 35′ W 48° 35′ S, 20° 35′ W 48° 00′ S, 18° 50′ W	Probable ,, ,, ,, ,,	Surf. temps. only at Sts. By thermograph crossing loops near St. 835 at 0300, 0730, 1500, and 1900 hr. on 25th, and 0200 hr. on 26th.
49	,,	SE'ward from Cape Town	14. iv. 32	50° 25′ S, 31° 30′ E	Good	By min. temp. betw. Sts. 849 and 850. By thermograph at 2130 hr. Indication of long northward bend in convergence approaching ship's track betw. Sts. 848 and 849.
50	,,	NE'ward to Fremantle	1. v. 32	52° 00′ S, 95° 50′ E	Probable	By min. temp. S of St. 866. By thermograph at 1500 hr., but loop comes near ship's track at 1800 hr. on 2nd.
51	,,	SE'ward from Fremantle	23. v. 32	52° 07′ S, 121° 35′ E	Approx.	By min. temp. near St. 883. By thermograph about 1500 hr.
52	,,	NE'ward to Melbourne	31. v. 32	54° 25′ S, 136° 00′ E	Good	By min. temp. betw. Sts. 891 and 892. By thermograph at 1000 hr.
53	,,	S'ward from Melbourne	20. vi. 32	53° 45′ S, 151° 33′ E 54° 15′ S, 151° 55′ E 55° 00′ S, 152° 00′ E	,, ,, ,,	By min. temp. near St. 903. By thermograph at 0200 hr. with loop at 0630 and 1200 hr.
54	,,	N'ward to N. Zealand	27. vi. 32	54° 30′ S, 162° 35′ E	V. good	By min. temp. near St. 920. By thermograph at 0130 hr.
55	,,	SE'ward from N. Zealand	7. ix. 32	57° 50′ S, 165° 35′ W	Probable	By min. temp. near St. 949. By thermograph probably at 1000 hr.
56	,,	NE'ward betw. 150° and 140° W	13. ix. 32 14. ix. 32 14. ix. 32	55° 30′ S, 144° 55′ W 53° 45′ S, 141° 45′ W 53° 05′ S, 140° 50′ W	Good ,, ,,	By min. temp. betw. Sts. 961 and 962. By thermograph at about 0700 hr. Well-defined loop of Antarctic water 0530 to 1100 hr. on 14th betw. Sts 962 and 963.
57	,,	SE'ward in 113° W	26. ix. 32	56° 55, S, 113° 25′ W	Probable	By min. temp. betw. Sts. 970 and 972. By thermograph at 0100 hr.
58	,,	NE'ward to Magellan Str.	30. ix. 32	61° 10′ S, 93° 20′ W 60° 20′ S, 91° 15′ W 60° 10′ S, 90° 45′ W	,, ,, ,,	By min. temp. betw. Sts. 975 and 976. By thermograph at 0330 hr., with loop of Antarctic water at 1130 and 1300 hr.
59	,,	S'ward in 80° W	28. x. 32	62° 45′ S, 80° 00′ W	V. good	By min. temp. betw. Sts. 990 and 991. By thermograph at 0500 hr.
60	,,	S. Shetlands to Falkland Is.	9. xi. 32	55° 17′ S, 56° 00′ W	,,	By min. temp. betw. Sts. 1017 and 1018. By thermograph at 0500 hr.
61	,,	S'ward in 45° W	18. xi. 32	51° 20′ S, 44° 41′ W	Uncertain	By min. temp. near St. 1027. By thermograph indeterminate.
62	,,	North of S. Georgia	4. xii. 32	49° 35′ S, 36° 35′ W	V. good	By min. temp. betw. Sts. 1054 and 1055. By thermograph at 0400 hr.
63	,,	,, ,, ,,	4. xii. 32	50° 28′ S, 36° 57′ W	,,	By min. temp. betw. Sts. 1055 and 1056. By thermograph at 2300 hr. just S of 1056.
64	,,	S. Shetlands to Falkland Is.	7. ii. 33	58° 20′ S, 60° 35′ W	Approx.	By min. temp. S of St. 1117. By thermograph probably at 1600 hr.
65	,,	Falkland Is. to S. Georgia	21. ii. 33	52° 13′ S, 47° 25′ W	Uncertain	By min. temp. E of St. 1123. By thermograph at 0400 hr.
66	,,	N'ward in 13° E	20. iii. 33	48° 30′ S, 13° 30′ E	,,	By min. temp. S of St. 1162. Thermograph suggests 0900 hr.

Table 9 (*cont.*)

No.	Ship	Voyage	Date	Estimated position	Degree of accuracy	Remarks
67	'Discovery II'	Tristan to S. Georgia	23. xi. 33 24. xi. 33 24. xi. 33 25. xi. 33 25. xi. 33	47° 56′ S, 23° 10′ W 48° 30′ S, 25° 15′ W 49° 04′ S, 26° 10′ W 49° 48′ S, 28° 03′ W 49° 55′ S, 28° 34′ W	Probable ,, ,, ,, ,,	By min. temp. betw. Sts. 1190 and 1198. Conditions confused at intermediate stations. Loops probably crossed at 1500 hr. on 23rd, 0830 and 1330 hr. on 24th, and 0300 and 0530 hr. on 25th. Course of convergence very confused.
68	,,	N'ward in 78° W	16. xii. 33	61° 40′ S, 78° 00′ W	,,	By min. temp. near St. 1224. By thermograph at 0400 hr.
69	,,	S'ward from Falkland Is.	29. xii. 33 29. xii. 33 29. xii. 33 29. xii. 33 29. xii. 33 29. xii. 33 29. xii. 33 30. xii. 33 30. xii. 33	55° 24′ S, 60° 10′ W 55° 30′ S, 60° 15′ W 55° 48′ S, 60° 28′ W 56° 25′ S, 60° 45′ W 57° 20′ S, 61° 30′ W 57° 40′ S, 61° 48′ W 57° 58′ S, 62° 05′ W 58° 20′ S, 62° 25′ W 58° 45′ S, 62° 50′ W	V. good ,, ,, ,, ,, ,, ,, ,, ,,	By min. temp. betw. Sts. 1233 and 1234. By thermograph a series of loops or patches at 0030, 0200, 0330, 0730, 1400, 1600, 1800, 0100 and 0400 hr.
70	,,	N'ward to Auckland	22. i. 34	57° 58′ S, 170° 45′ W	Uncertain	By min. temp. S of St. 1276. Thermograph indeterminate, but 0800 hr. adopted for position.
71	,,	N. Zealand to Ross Sea	19. ii. 34	60° 47′ S, 174° 50′ W	,,	No. adj. Sts. Thermograph suggests 1200 hr.
72	,,	N'ward in 79° W	12. iii. 34	63° 30′ S, 79° 08′ W	Probable	By min. temp. near St. 1315. By thermograph at 0600 hr., but ship near convergence until 0400 on 13th.
73	,,	Falkland Is. to Elephant I.	29. iii. 34	56° 35′ S, 55° 40′ W	V. good	By min. temp. betw. Sts. 1325 and 1326. By thermograph at 0400 hr.
74	,,	NW of S. Georgia	8. iv. 34	51° 20′ S, 44° 09′ W	Good	By min. temp. betw. Sts. 1337 and 1338. By thermograph at 0500 hr.
75	,,	,, ,, ,,	8. iv. 34	51° 20′ S, 42° 40′ W	,,	By min. temp. betw. Sts. 1338 and 1339. By thermograph at 1700 hr.
76	,,	Enderby Land to Durban	15. v. 34	50° 20′ S, 44° 54′ E	,,	By min. temp. betw. Sts. 1366 and 1367. By thermograph at 0200 hr.
77	,,	Cape Town to S. Georgia	11. viii. 34	48° 55′ S, 04° 15′ W	V. uncertain	Surf. temps. only at Sts. Thermograph indeterminate, but crossing perhaps at 0730 hr.
78	,,	SW'ward to S. Georgia	21. viii. 34 22. viii. 34 23. viii. 34 23. viii. 34	47° 40′ S, 23° 56′ W 48° 57′ S, 25° 40′ W 49° 45′ S, 26° 50′ W 49° 55′ S, 27° 05′ W	Good Uncertain Probable ,,	By min. temp. near St. 1391. By thermograph sub-Antarctic water SW of 1391 but not SE of it. Crossings at 1400 hr. on 21st, about 2000 hr. on 22nd, and 0400 and 0530 hr. on 23rd.
79	,,	S. Georgia to S. Shetlands	4. ix. 34 5. ix. 34	55° 40′ S, 44° 20′ W 56° 03′ S, 45° 20′ W	Good ,,	Surf. temps. only at Sts. By thermograph ship's track cuts loop of convergence SW of S. Georgia at 1900 and 0300 hr.
80	,,	N'ward in 78° W	13. ix. 34	61° 25′ S, 78° 30 W	Approx.	By min. temp. betw. Sts. 1416 and 1417. By thermograph about 1800 hr.
81	,,	Falkland Is. to Elephant I.	26. ix. 34	56° 20′ S, 55° 40′ W	V. good	By min. temp. betw. Sts. 1424 and 1425. By thermograph at 0700 hr.
82	,,	N'ward in 46° W	1. x. 34 2. x. 34	56° 06′ S, 45° 47′ W 55° 12′ S, 45° 45′ W	Good ,,	Surf. temp. only at St. By thermograph ship's track cuts loop of convergence SW of S. Georgia at 1700 and 0500 hr.
83	,,	NW of S. Georgia	3. x. 34	51° 55′ S, 45° 21′ W	,,	By min. temp. betw. Sts. 1434 and 1435. By thermograph at 2100 hr.
84	,,	,, ,, ,,	5. x. 34	51° 20′ S, 42° 25′ W	,,	By min. temp. S of St. 1435. By thermograph at 0200 hr.
85	,,	S. Georgia to Falkland Is.	12. x. 34	52° 48′ S, 47° 57′ W	,,	By min. temp. betw. Sts. 1439 and 1440. By thermograph at 0300 hr.
86	,,	S'ward in 79° W	29. x. 34	62° 10′ S, 79° 28′ W	,,	By min. temp. betw. Sts. 1446 and 1447. By thermograph at 0500 hr.
87	,,	E'ward betw. 105° and 96° W	9. xi. 34 10. xi. 34 10. xi. 34 11. xi. 34 11. xi. 34 11. xi. 34	61° 02′ S, 105° 05′ W 60° 15′ S, 100° 45′ W 60° 03′ S, 99° 30′ W 59° 35′ S, 97° 15′ W 59° 33′ S, 96° 28′ W 59° 40′ S, 96° 10′ W	,, ,, ,, ,, ,, ,,	By min. temp. St. 1467 very close to convergence. By thermograph crossing loops at 2100 hr. on 9th, 1230 and 1700 hr. on 10th, and 0430, 0830 and 1330 hr. on 11th.

Table 9 (*cont.*)

No.	Ship	Voyage	Date	Estimated position	Degree of accuracy	Remarks
88	'Discovery II'	N'ward in 80° W	17. xi. 34	60° 20′ S, 79° 54′ W	Uncertain	By min. temp. close to St. 1476. By thermograph doubtful.
89	'W. Scoresby'	SE'ward from Cape Town	xi. xii. 34	?	—	No adj. Sts. Convergence doubtful by ship's T.s. 30. xi. or 1. xii. 34.
90	'Discovery II'	Falkland Is. to S. Shetlands	4. xii. 34 4. xii. 34 4. xii. 34 5. xii. 34	56° 05′ S, 59° 00′ W 56° 55′ S, 59° 20′ W 57° 54′ S, 59° 45′ W 59° 47′ S, 60° 20′ W	V. good ,, ,, Good	No adj. Sts. By thermograph at 0030, 0700 and 1430 hr. on 4th. Rise of temp. to 2·4 centred at 0800 hr. on 5th indicates proximity of a loop of the convergence.
91	,,	N'ward in 44° W	25. i. 35	52° 06′ S, 44° 05′ W	,,	By min. temp. at St. 1495. By thermograph at St. 1495.
92	,,	NW'ward to Cape Town	7. iii. 35	49° 50′ S, 31° 05′ E	,,	By min. temp. betw. Sts. 1552 and 1553. By thermograph at 0400 hr.
93	'W. Scoresby'	NE'ward to Cape Town	24. iii. 35	50° 57′ S, 05° 15′ E	Uncertain	No adj. Sts. By ship's T.s probably about 1000 hr.
94	'Discovery II'	E'ward betw. 20° and 35° E	2. iv. 35 5. iv. 35 5. iv. 35 6. iv. 35	48° 50′ S, 20° 45′ E 49° 35′ S, 29° 07′ E 49° 30′ S, 31° 00′ E 48° 40′ S, 34° 10′ E	Good ,, ,, Approx.	By min. temp. St. 1561 in Antarctic water. By thermograph crossings at 1100 hr. on 2nd, 0500 and 1600 hr. on 5th, and about 0900 hr. on 6th. Pronounced bend in convergence about 30° E. Cf. No. 49, 14. iv. 32.
95	,,	S'ward in 56° E	20. xi. 35	48° 08′ S, 56° 30′ E	Uncertain	By min. temp. near St. 1618. By thermograph probably 0800 hr. on 20th.
96	,,	NE'ward to Fremantle	7. xii. 35	52° 30′ S, 117° 05′ E	Probable	No adj. Sts. By thermograph at 1700 hr.
97	'W. Scoresby'	S'ward from Cape Town	9. xii. 35	49° 20′ S, 18° 48′ E	,,	No. adj. Sts. By ship's T.s about 1600 hr.
98	'Discovery II'	N. Zealand to Ross Sea	6. i. 36	60° 22′ S, 178° 15′ E	,,	No adj. Sts. By ship's T.s about 2100 hr.
99	,,	Balleny Is. to Melbourne	8. ii. 36	57° 20′ S, 163° 00′ E	Approx.	By min. temp. betw. Sts. 1679 and 1680. By ship's T.s about 0600 hr.
100	,,	S'ward from Melbourne	9. iii. 36	53° 20′ S, 146° 44′ E	Good	By min. temp. betw. Sts. 1690 and 1691. By ship's T.s near 1200 hr.
101	'W. Scoresby'	N'ward to Cape Town	29/30. iii. 36	?	—	No adj. Sts. Indeterminate by ship's T.s.
102	'Discovery II'	N'ward to Fremantle	2. iv. 36	48° 05′ S, 109° 47′ E	Good	By min. temp. N of St. 1730. By ship's T.s near 1730 hr.
103	,,	S'ward in 0°	29. v. 36	49° 37′ S, 00° 06′ E	Probable	By min. temp. near St. 1777. By ship's T.s about 1400 hr.
104	,,	N'ward to Cape Town	12. vi. 36	48° 40′ S, 18° 50′ E	Approx.	By min. temp. S of St. 1798. By ship's T.s about 1200 hr.
105	,,	S'ward in 0°	26. ix. 36	49° 54′ S, 00° 06′ E	Uncertain	By min. temp. betw. Sts. 1810 and 1812. By thermograph about 1200 hr.
106	,,	NW of S. Georgia	5. xi. 36	51° 10′ S, 41° 40′ W	Good	By min. temp. near St. 1857. By thermograph at 0400 hr.
107	,,	,, ,, ,,	6. xi. 36	52° 04′ S, 43° 00′ W	Approx.	By min. temp. N of St. 1860. By thermograph about 1600 hr.
108	,,	S'ward in 43° W	7. xi. 36	54° 10′ S, 42° 50′ W	,,	Surf. temp. only at St. By thermograph rise of temp. to 3·0 centred about 1200 hr. indicates proximity of loop of convergence.
109	,,	Elephant I. to Falkland Is.	15. xi. 36	57° 08′ S, 55° 15′ W	V. good	By min. temp. N of St. 1877. By thermograph at 0300 hr.
110	'W. Scoresby'	S'ward from Cape Town	1. xii. 36	47° 58′ S, 13° 03′ E	Good	No adj. Sts. By ship's T.s about 1800 hr.
111	'Discovery II'	E'ward to S. Georgia	3. xii. 36	53° 35′ S, 48° 30′ W	Uncertain	By min. temp. E of St. 1916. By thermograph about 0300 hr.
112	,,	S. Orkneys to Falkland Is.	17. ii. 37	56° 45′ S, 51° 40′ W	V. good	By min. temp. S of St. 1969. By thermograph at 1600 hr.
113	,,	Falkland Is. to S. Georgia	2. iii. 37	53° 25′ S, 45° 30′ W	Uncertain	By min. temp. near St. 1975. By thermograph about 0230 hr.
114	'W. Scoresby'	N'ward to Cape Town	19. iii. 37	48° 20′ S, 11° 25′ E	,,	No adj. Sts. By ship's T.s perhaps at 2200 hr.
115	'Discovery II'	N'ward in 0°	28. iii. 37	49° 50′ S, 00° 20′ E	Approx.	By min. temp. betw. Sts. 2022 and 2023. By thermograph probably at 2300 hr.

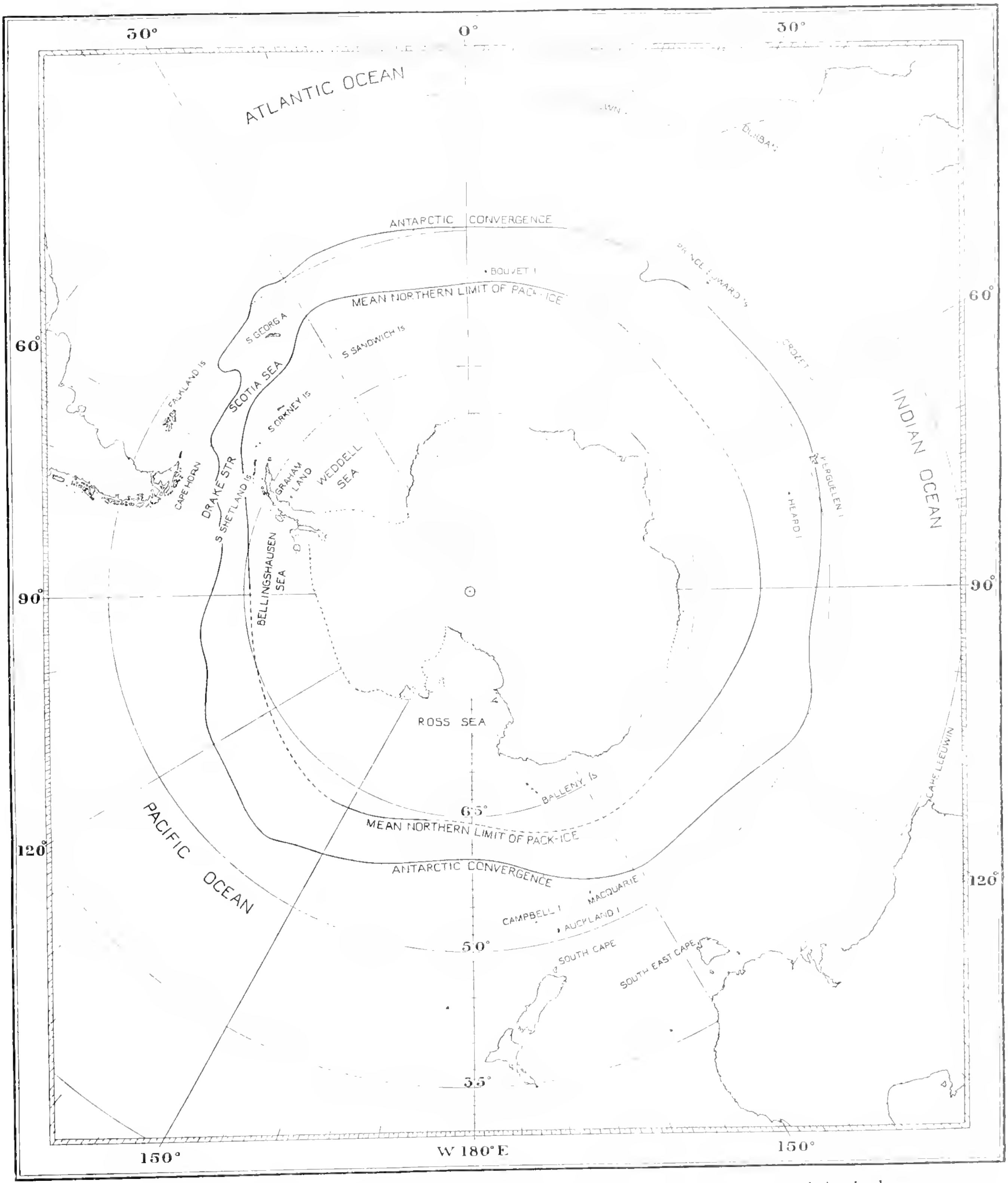
Table 9 (*cont.*)

No.	Ship	Voyage	Date	Estimated position	Degree of accuracy	Remarks
116	'W. Scoresby'	Whale marking betw. Montevideo and S. Georgia	27. x. 37 28. x. 37 30. x. 37 5. xi. 37	47° 32′ S, 33° 12′ W 49° 00′ S, 30° 32′ W 50° 04′ S, 32° 10′ W 48° 20′ S, 33° 12′ W	Probable ,, Good Probable	Complex movements by ship and v. sharp fluctuations of temp. by thermograph. Loop of convergence approached at 0015 hr. on 27th. Crossings at 0600 hr. on 28th, 1300 hr. on 30th and 0500 hr. on 5th. Loops possibly shifted betw. 27. x. and 5. xi. 37.
117	'Discovery II'	SE'ward from Cape Town	19. xi. 37	47° 05′ S, 25° 00′ E	Uncertain	By min. temp. N of St. 2088. By thermograph at 0100 hr., S of St. Latter position adopted.
118	,,	NE'ward to Fremantle	10. xii. 37	52° 12′ S, 98° 25′ E	Probable	Obscure by min. temp. By thermograph probably at 1100 hr.
119	,,	S'ward from Fremantle	5. i. 38 5. i. 38 6. i. 38	49° 47′ S, 115° 47′ E 50° 00′ S, 115° 47′ E 51° 12′ S, 115° 50′ E	,, ,, ,,	By min. temp. near St. 2158. By thermograph at 1500 and 1700 hr. on 5th and 0800 hr. on 6th. Track close to convergence from 1700 to 0800 hr.
120	,,	N'ward to N. Zealand	24. i. 38	59° 30′ S, 165° 15′ E	Uncertain	By min. temp. near St. 2206. Thermograph shows rise in temp. before and after St. 2206.
121	,,	SE'ward from N. Zealand	14. ii. 38	59° 52′ S, 168° 45′ W	Probable	By min. temp. betw. Sts. 2220 and 2221. By thermograph at 1330 hr.
122	'W. Scoresby'	S. Shetlands to Falkland Is.	24. ii. 38	56° 47′ S, 58° 00′ W	V. good	No adj. Sts. By thermograph at 1000 hr.
123	'Discovery II'	NE'ward to Falkland Is.	13. iii. 38	57° 57′ S, 62° 15′ W	Probable	By min. temp. betw. Sts. 2288 and 2289. By thermograph at 0200 hr. Probably oblique crossing.
124	,,	Falkland Is. to S. Orkneys	22. iii. 38	56° 30′ S, 52° 15′ W	Good	By min. temp. betw. Sts. 2292 and 2293. By thermograph at 0900 hr.
125	,,	N'ward to Cape Town	29. iv. 38 29. iv. 38 30. iv. 38	49° 45′ S, 19° 22′ E 47° 50′ S, 19° 20′ E 46° 28′ S, 19° 18′ E	Approx. ,, ,,	By min. temp. betw. Sts. 2347 and 2348. By thermograph at 0300 and 1900 hr. on 29th and 0800 hr. on 30th.
126	,,	S'ward in 0°	10. vii. 38	50° 12′ S, 00° 32′ E	Good	By min. temp. betw. Sts. 2358 and 2359. By thermograph at 1330 hr.
127	,,	N'ward in 20° E	23. vii. 38	48° 20′ S, 21° 00′ E	,,	By min. temp. betw. Sts. 2377 and 2378. By thermograph at 0630 hr.
128	,,	S'ward in 0°	14. viii. 38	49° 28′ S, 00° 30′ E	Uncertain	By min. temp. S of St. 2387. By thermograph probably at 1500 hr.
129	,,	N'ward in 20° E	27. viii. 38	48° 30′ S, 20° 30′ E	Good	By min. temp. betw. Sts. 2416 and 2417. By thermograph at 1400 hr.
130	,,	S'ward in 0°	23. ix. 38	50° 00′ S, 00° 40′ E	Uncertain	By min. temp. betw. Sts. 2426 and 2428. By thermograph at 0100 hr. (doubtful).
131	,,	N'ward in 20° E	3. x. 38	48° 55′ S, 20° 00′ E	V. uncertain	By min. temp. betw. Sts. 2449 and 2450. By thermograph at 1300 hr. (doubtful).
132	,,	S'ward in 0°	26. x. 38	50° 06′ S, 02° 05′ E	Uncertain	By min. temp. N of St. 2461. By thermograph S of St. at 0300 hr.
133	,,	N'ward in 20° E	5. xi. 38	48° 10′ S, 20° 15′ E	Good	By min. temp. betw. Sts. 2481 and 2482. By thermograph at 0600 hr.
134	,,	S'ward in 0°	2. xii. 38	49° 45′ S, 01° 03′ E	Probable	By min. temp. betw. Sts. 2495 and 2496. By thermograph at 1600 hr.
135	,,	N'ward in 20° E	14. xii. 38	47° 55′ S, 19° 55′ E	,,	By min. temp. betw. Sts. 2521 and 2522. By thermograph at 0130 hr.
136	,,	S'ward in 0°	16. i. 39	49° 45′ S, 02° 48′ E	V. uncertain	By min. temp. S of St. 2533. By thermograph possibly at 0030 hr.
137	,,	N'ward in 20° E	3. ii. 39	48° 20′ S, 19° 45′ E	Probable	By min. temp. betw. Sts. 2573 and 2574. By thermograph at 1030 hr.
138	,,	S'ward in 0°	23. ii. 39	49° 33′ S, 01° 06′ E	Approx.	By min. temp. near St. 2585. By thermograph indeterminate.
139	,,	N'ward in 20° E	15. iii. 39	48° 20′ S, 19° 38′ E	Good	By min. temp. betw. Sts. 2622 and 2623. By thermograph at 1400 hr.

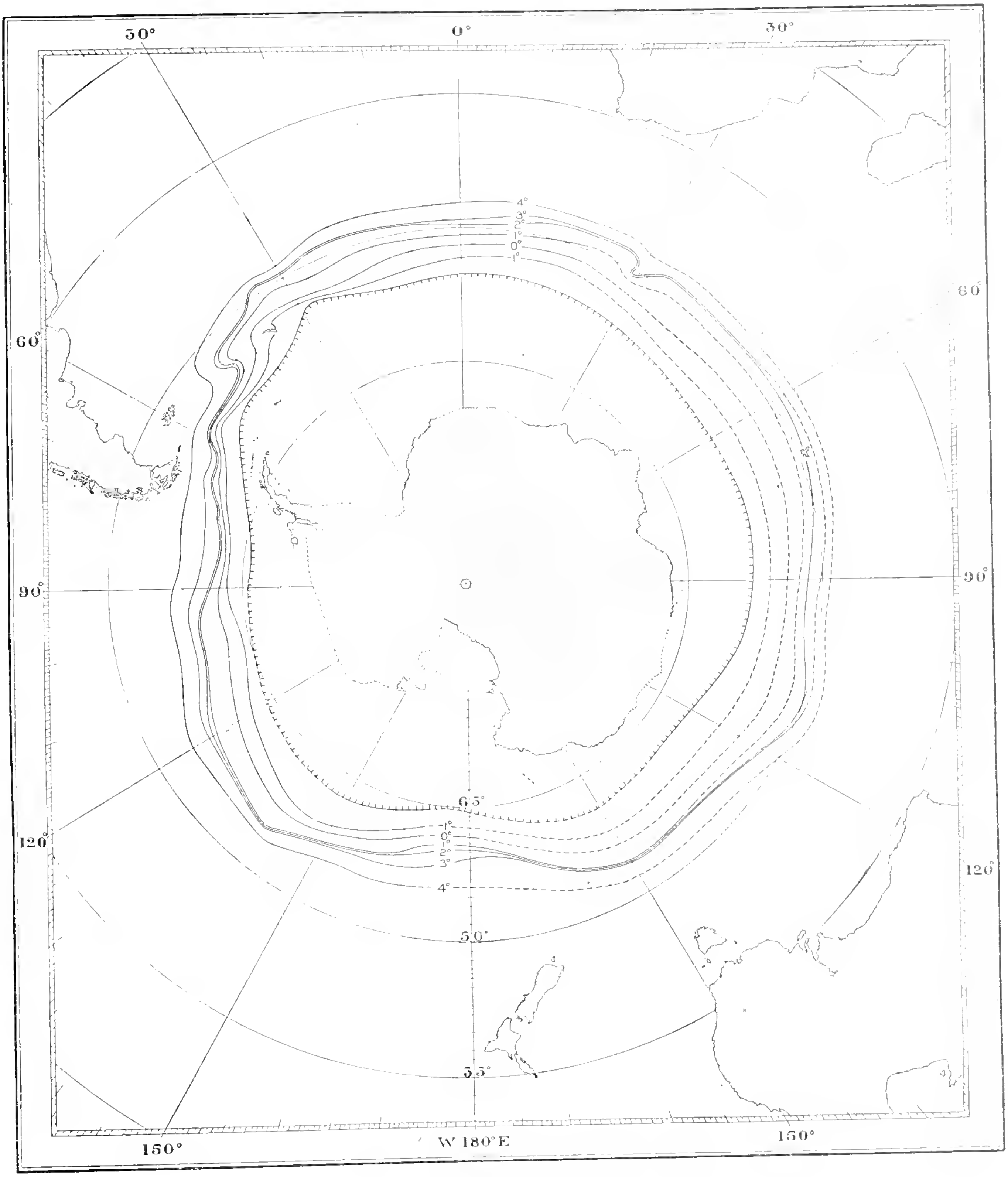
NOTES ON THE PLATES

Place-names are shown in Plate I.

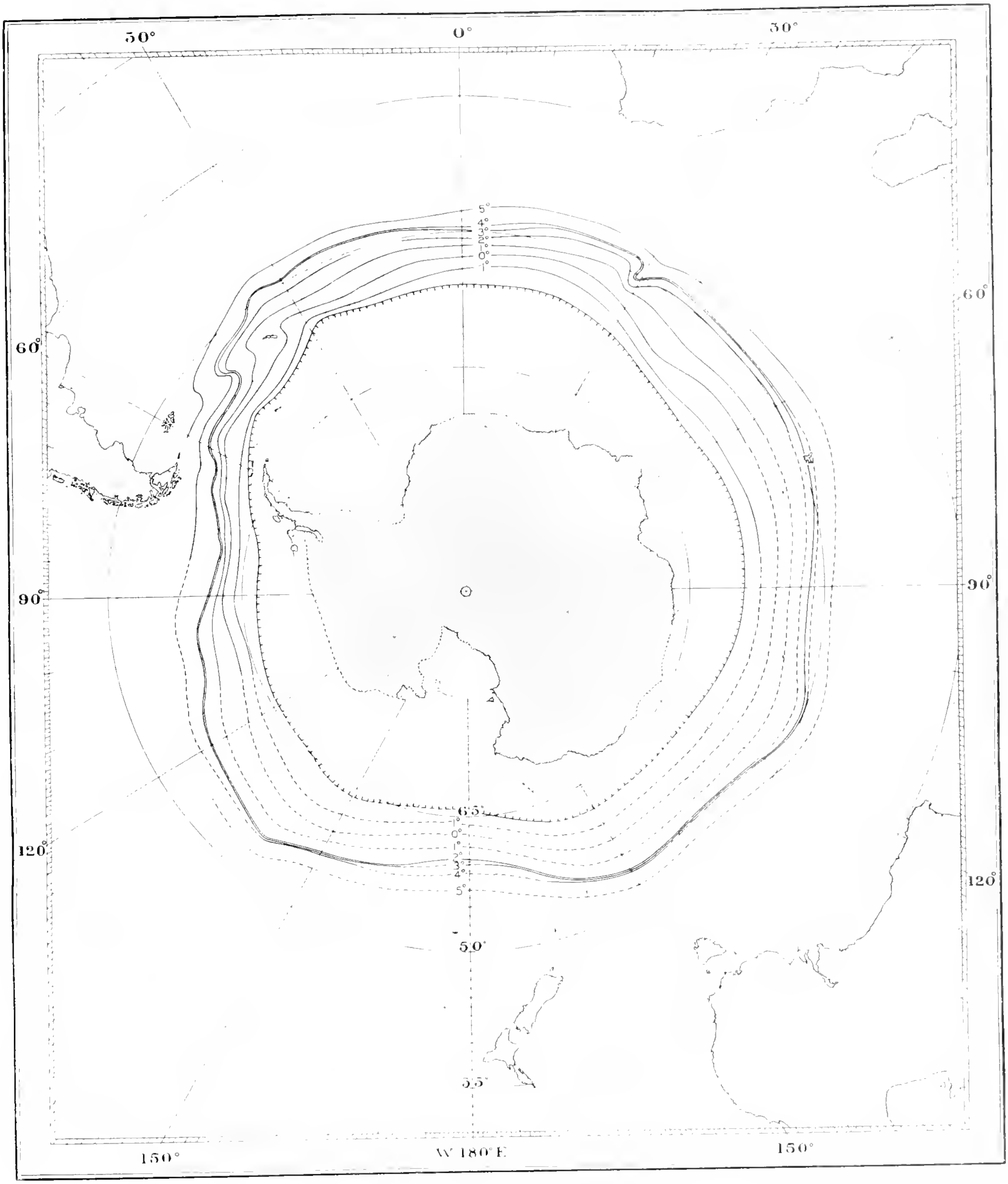
Plates II–XII show the mean surface isotherms for each month in Antarctic waters and for a short distance north of the Antarctic convergence. The pack-ice edge, shown by a hatched line, is in the mean position for each month, and is reproduced from Mackintosh and Herdman (1940) without alteration except at one point in Plate III between 10° and 100° W (see text, p. 199). The positions of thermograph records, and single observations included in the Discovery Committee's data, are shown in yellow; pecked lines in yellow represent ship's routine temperature readings.



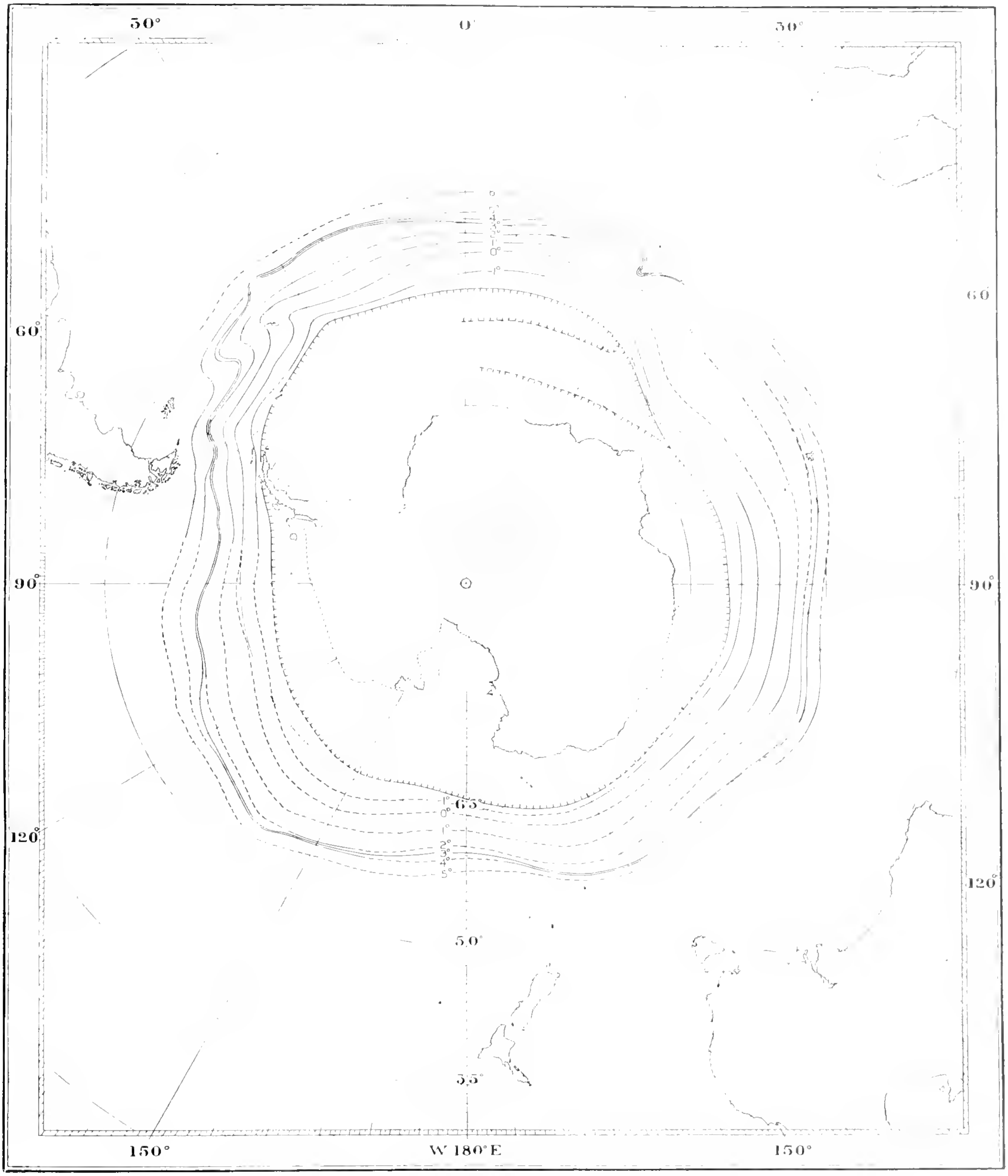
Estimated mean position of the Antarctic convergence. The mean northern limit of the pack-ice is the average position of the ice-edge for September reproduced from Mackintosh and Herdman (1940).



Surface temperatures, SEPTEMBER and OCTOBER.



Surface temperatures, NOVEMBER.

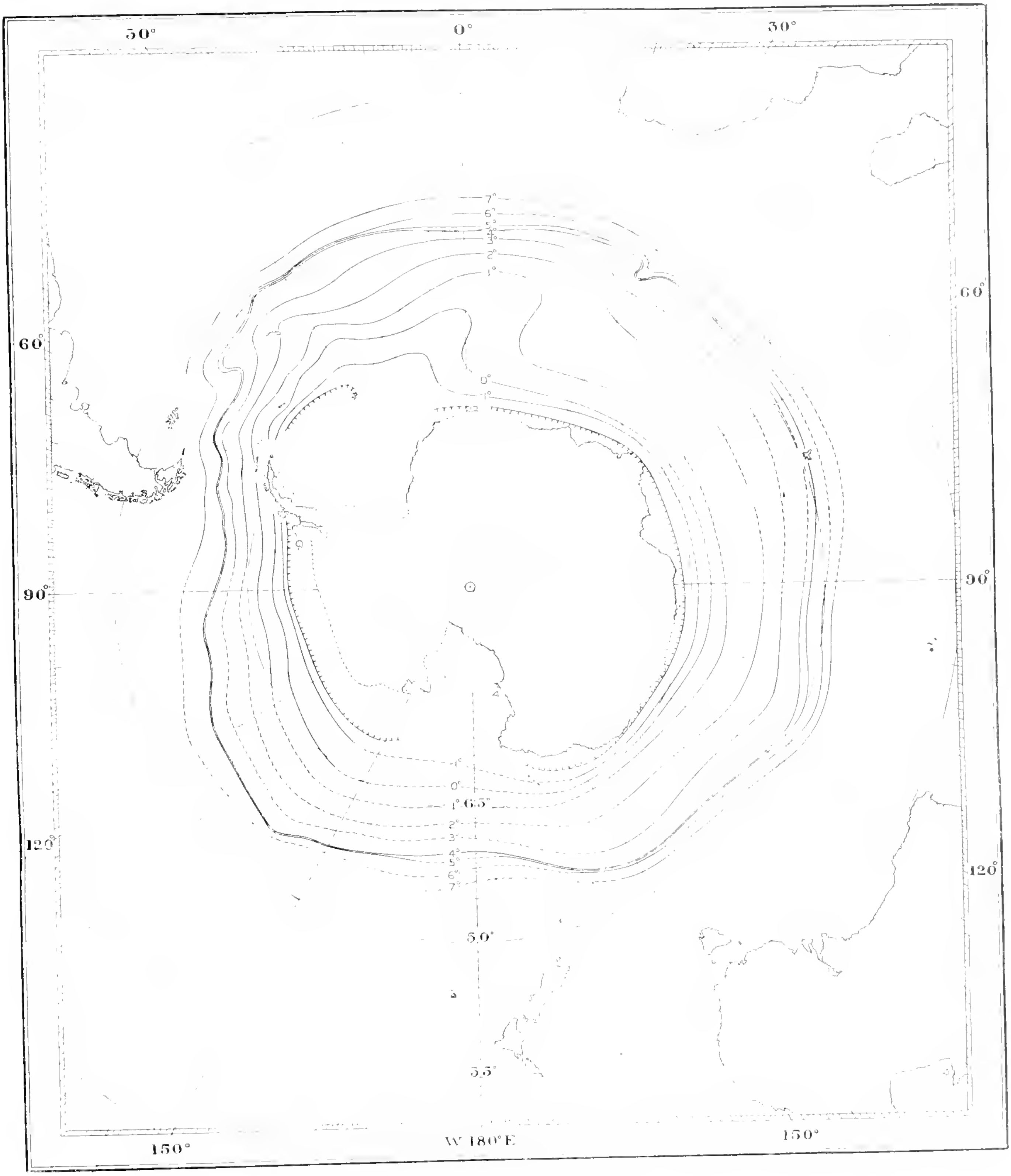


Surface temperatures, DECEMBER.

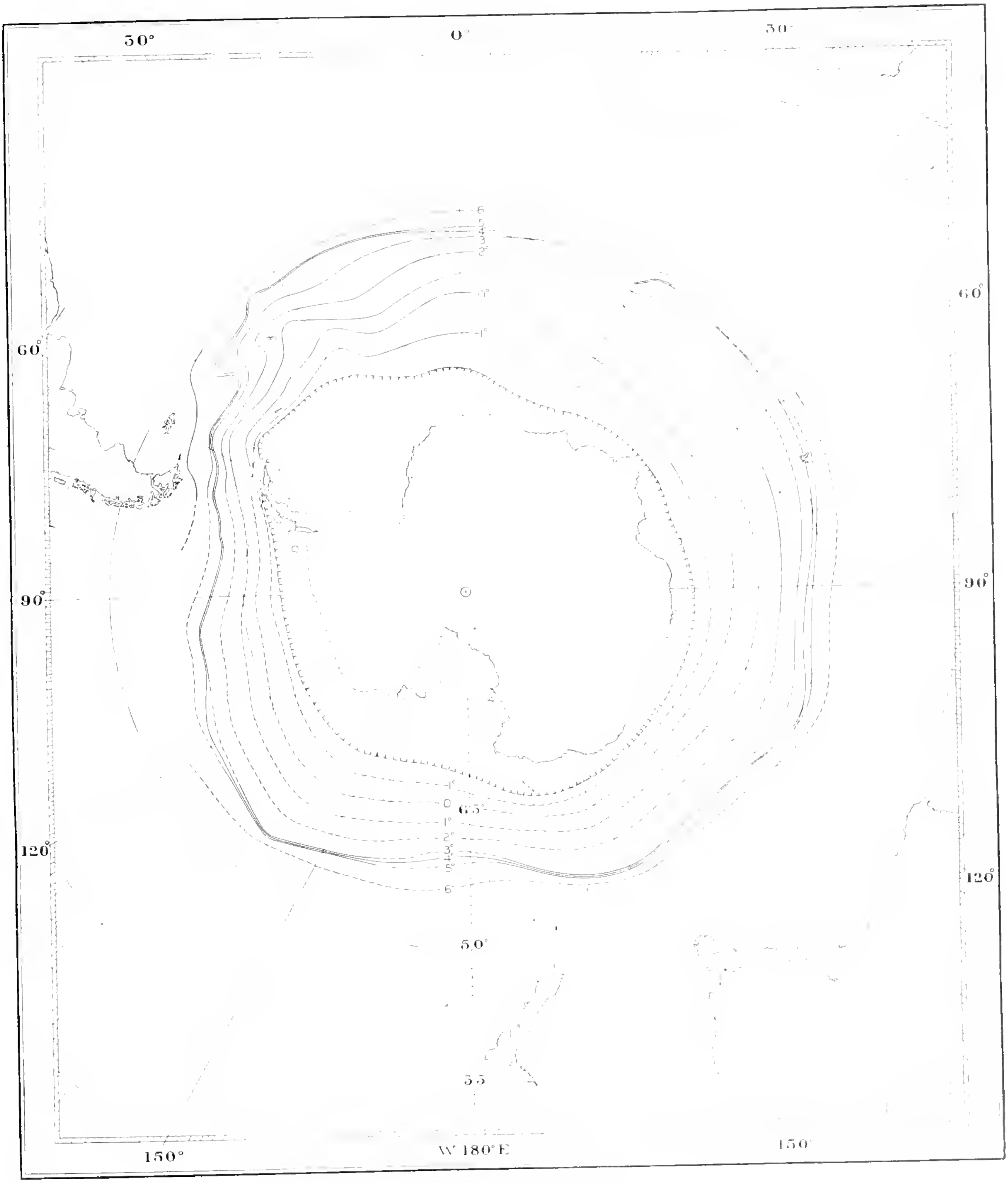
Surface temperatures, JANUARY.

Surface temperatures, FEBRUARY.

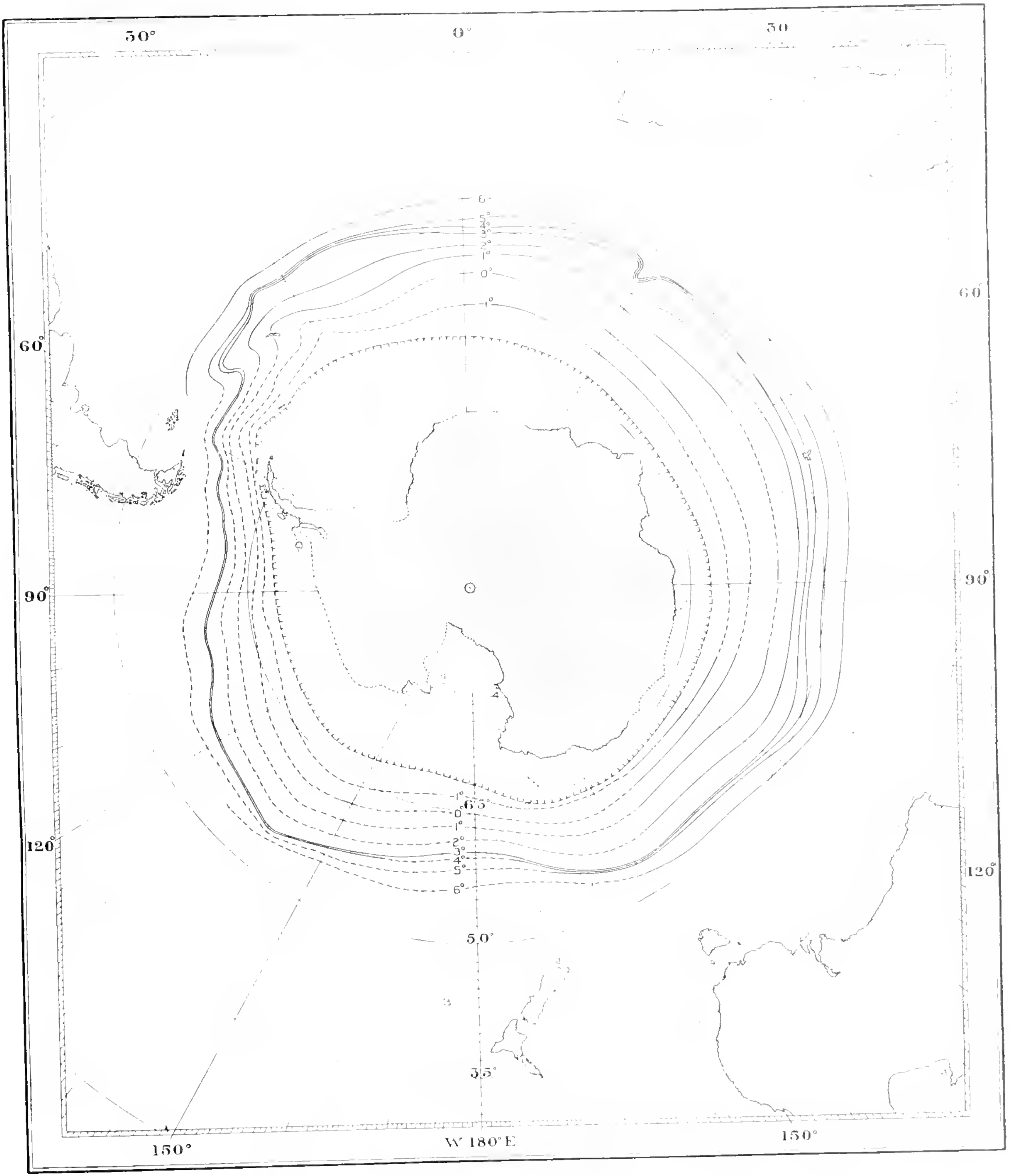
PLATE VII



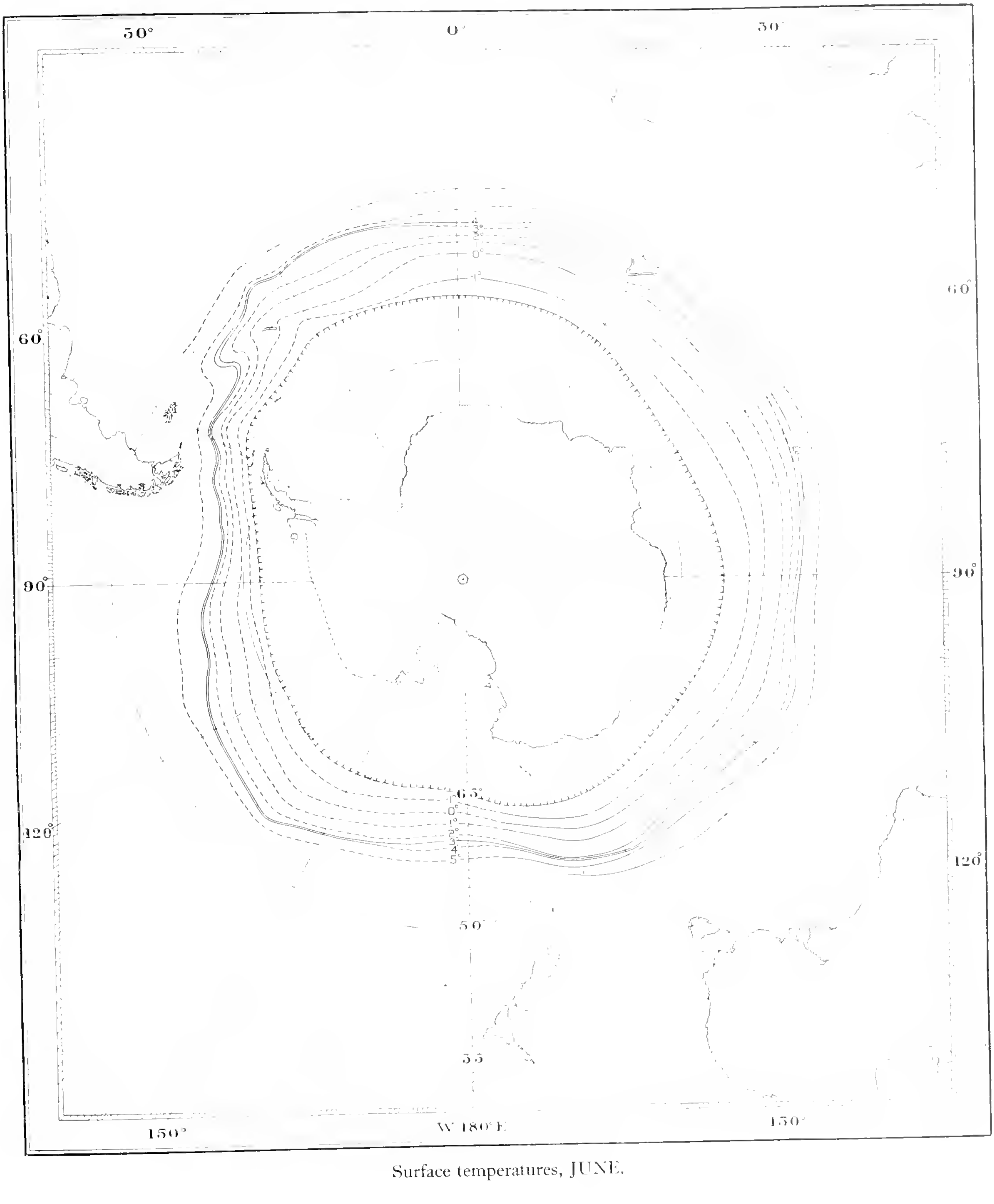
Surface temperatures, MARCH.



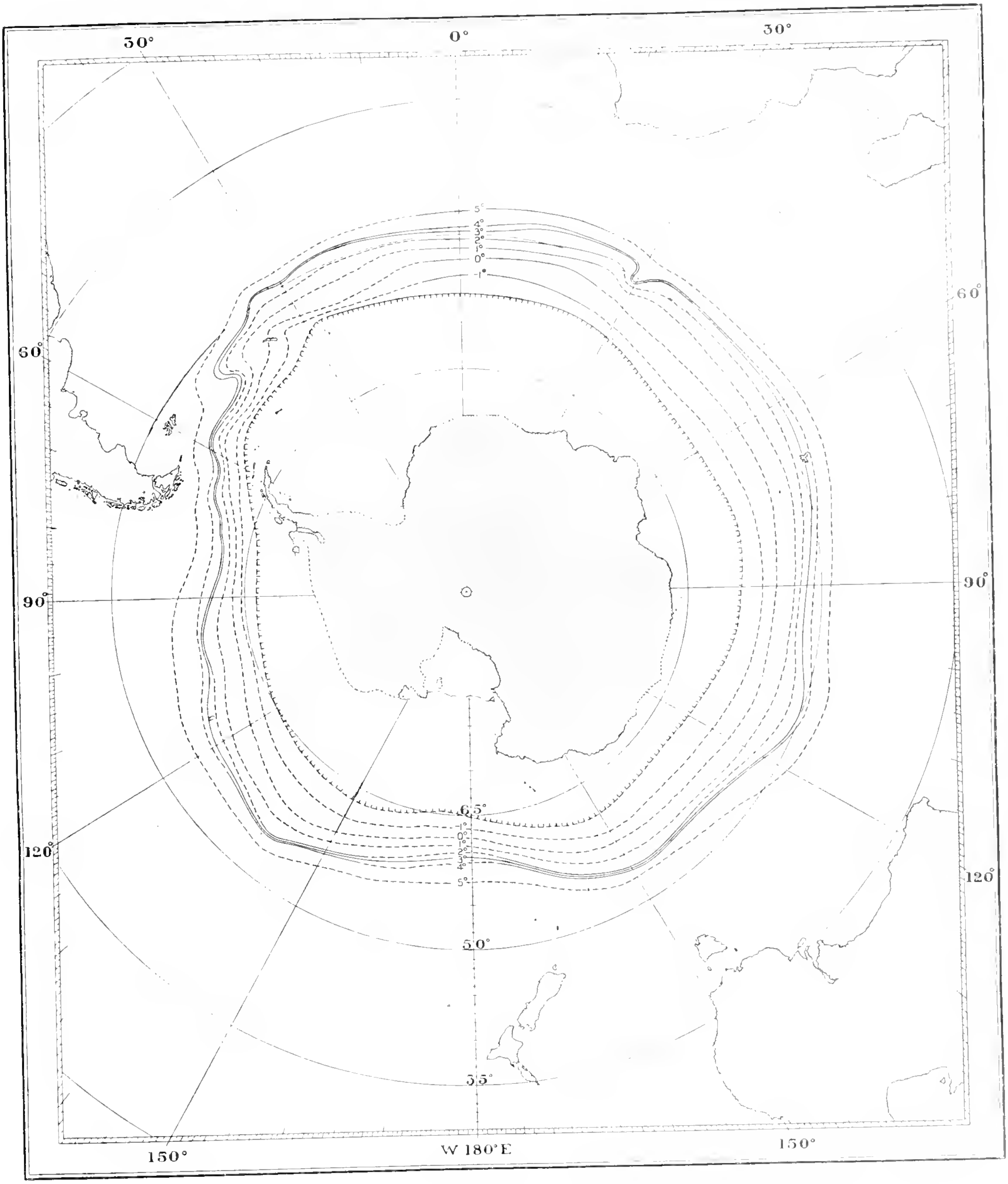
Surface temperatures, APRIL.



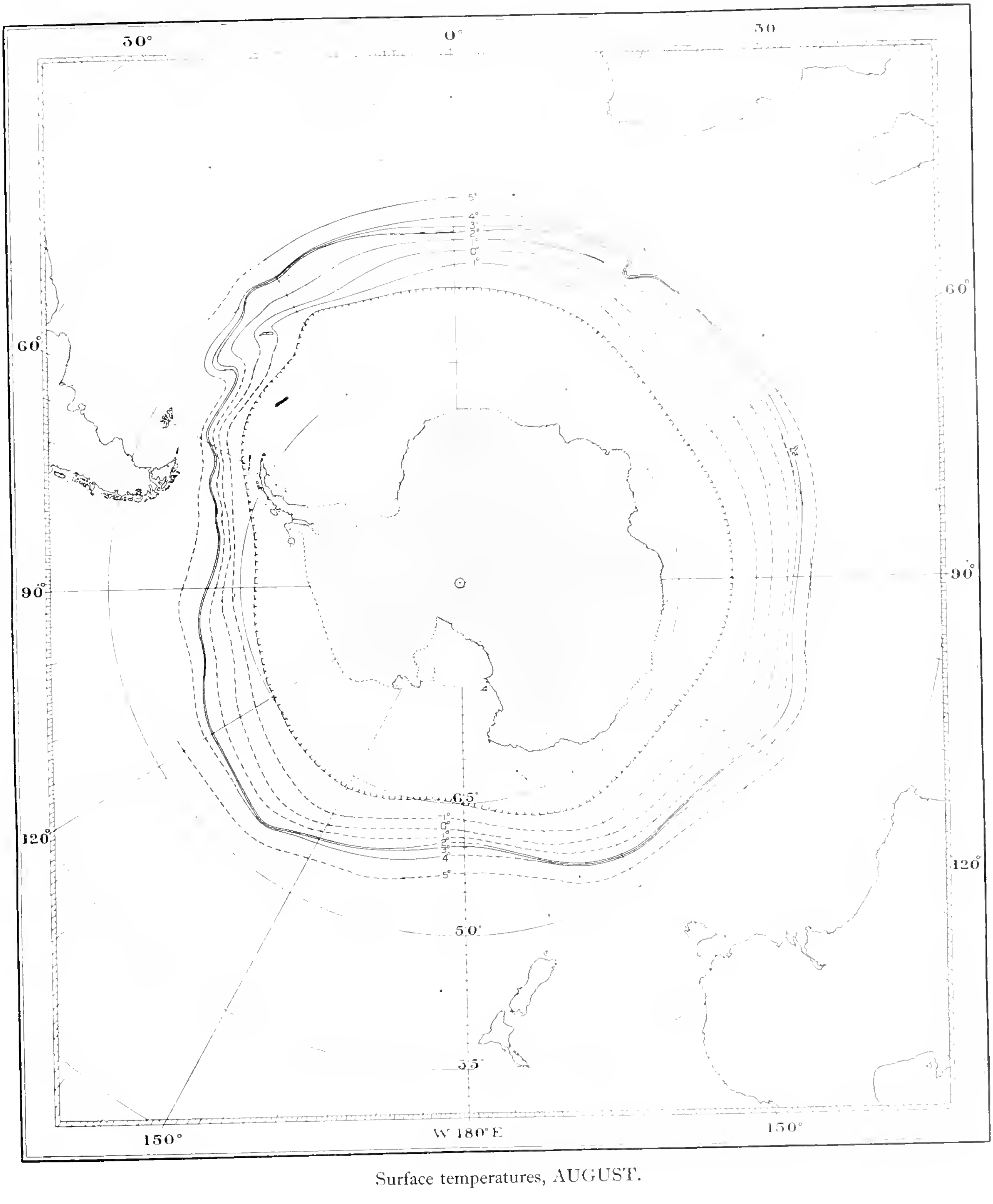
Surface temperatures, MAY.



Surface temperatures, JUNE.

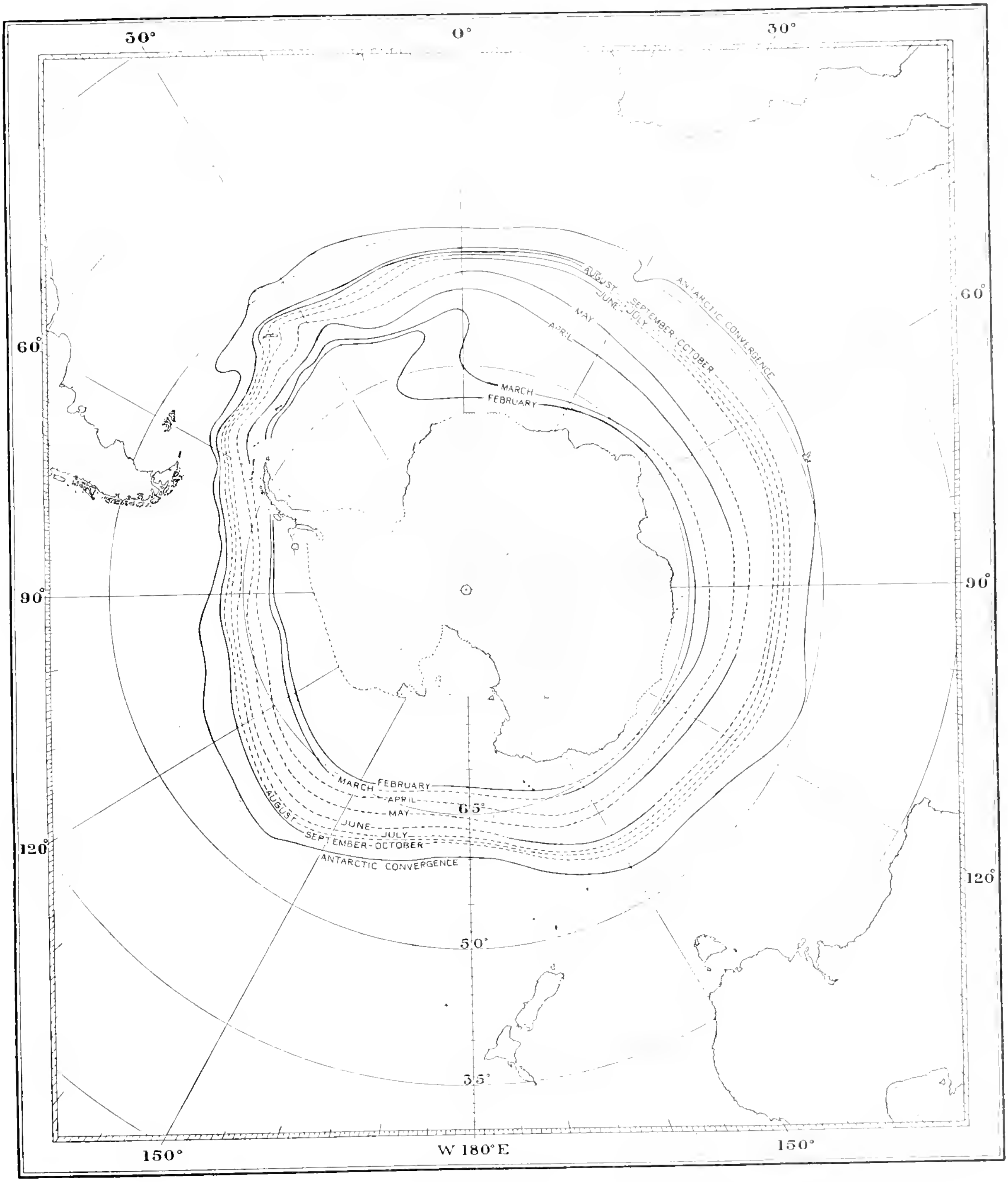


Surface temperatures, JULY.



Surface temperatures, AUGUST.

0° ISOTHERM, summer months.



0° ISOTHERM, winter months.

[*Discovery Reports. Vol. XXIII, pp.* 213–222, *Plate XV, August* 1946.]

NEBALIOPSIS TYPICA

By

H. GRAHAM CANNON, Sc.D., F.R.S.

NEBALIOPSIS TYPICA

By H. Graham Cannon, Sc.D., F.R.S.
Beyer Professor of Zoology in the Victoria University of Manchester

(Plate XV)

THE FORM OF THE BODY

In a recent report which has just reached this country, Linder (1943) has called in doubt the shape and configuration of *Nebaliopsis typica* which I described in an earlier Discovery Report (1931) and illustrated by photographs of a specimen which I stated (loc. cit. p. 201) was complete and undamaged. The only specimen which, previous to my report, had reached the surface intact, I stated on the authority of Dr Odhner of the Riksmuseum, Stockholm, was most probably lost. Dr Linder has now found the missing specimen, and it is this that he maintains represents the normal appearance of this rare deep-sea crustacean. My specimen was labelled F 2, and was illustrated by three untouched photographs on plate xxxii, and text-figs. 1 and 2, based on these photographs. Linder's chief criticism is that the cephalothorax is distended, more especially in the posterior part, while the carapace has remained unaffected (loc. cit. p. 5). As a result, part of the thorax is not covered by the lateral carapace, and the length of the carapace relative to the rest of the body is abnormally small. The difference is very marked by measuring Linder's figure and my own. A comparison shows that the length of the cephalothorax in his specimen is about 54 % that of the carapace, while in my specimen it is 96 %. Obviously such a large difference calls for further investigation.

I pointed out (loc. cit. p. 202) that measurements of all the specimens I had, together with that of the specimen we may now call Linder's, established the existence of a considerable variation in the length of the carapace and left the matter at that. I took the view that there was no doubt about it as, while Linder's specimen and mine were both presumably as perfect as could be, his had a large carapace and mine had a small one. I was relying for details of Linder's specimen on a sketch which had been published by Ohlin (1904, fig. 1). From this, however unsatisfactory it might have been in other respects, there was no doubt about the length of the carapace—it was relatively long. The question to be settled is whether the relative shortness of the carapace of my specimen F 2 is abnormal.

Linder's explanation (loc. cit. p. 6) is that at the great depths at which *Nebaliopsis* lives, there must be inside the body an enormous pressure. This is a point which no one will dispute. However, he then says that as the specimen is brought to the surface in the collecting gear this pressure inside, acting in all directions, enlarges the body so that by the time atmospheric pressure is reached at the surface the body is completely distended. This distension will occur to different degrees in different parts, and Linder assumes that the carapace is not affected by the pressure. Hence it retains its normal size while the body becomes bloated, and thus the carapace appears abnormally short.

Now this argument represents a widespread fallacy, a fallacy which has arisen first from the known fact that specimens of deep-sea fish are occasionally completely distended when they reach the surface, and secondly from the persistent and erroneous belief that sea water is much more dense at great depths than at the surface. Actually Linder's argument is valid, and then to a very uncertain degree, only if the body of *Nebaliopsis* contained gas.

As long as the body contains no bubble of gas, no such distension as Linder describes can take place. Now there is no reason to suppose that the body of *Nebaliopsis* contains gas any more than one may expect to encounter gas on opening up a lobster. Its body can be looked upon very largely as a mass of aqueous liquid and, moreover, a liquid closely similar in its physical properties to sea water. Now sea water, like other liquids, is only slightly compressible, or, more emphatically, is practically incompressible. The coefficient of compressibility of sea water is roughly 44×10^{-6}, which means that at the depth of a mile—the depth at which *Nebaliopsis* is known to occur—the density of sea water would only be 1/130 the greater. From this figure a rough computation shows that a specimen such as *Nebaliopsis*, if lowered to a depth of a mile, would diminish in length by approximately 1/400. Clearly, then, a specimen raised up from 1 mile would expand by 1/400 of its length, that is, by an imperceptible amount that would be extremely difficult to measure. Obviously such an expansion would lead to nothing like the distension of my specimen F 2.

I have stated that the presence of gas in a specimen, such, for instance, as occurs in the air bladder of a bony fish, would make a considerable difference to the above argument, for a gas, unlike a liquid, is extremely compressible. Now the pressure at a depth of 2000 m. is approximately 200 atm. Hence, if there were a bubble of gas in such a specimen at such a depth it would enlarge to 200 times its original volume by the time it was drawn up to the surface, or roughly a bubble the size of a pin's head at the depth of $1\frac{1}{4}$ miles would expand to the size of a pea at the surface. This is a considerable expansion and is of the order that might produce the enlargement which Linder maintains has occurred in the Discovery specimen F 2. Is there any reason, therefore, to suppose that gas is produced in the body of *Nebaliopsis* as it is brought to the surface? It might be argued that as it passes upwards the resulting reduced pressure would cause the dissociation of the oxyhaemocyanin that is presumably present in its blood. But the solubility of a gas is proportional to its pressure, and hence oxygen at 2000 m. is 200 times as soluble at the surface. Hence any oxygen which might be set free from the dissociation of the oxyhaemocyanin would immediately go into simple solution. For the sake of argument, however, let us suppose that the dissociation took place so quickly that there was not sufficient time for the oxygen to become dissolved before the animal reached the surface. What would be the result? Most probably the animal would burst under the strain of the sudden expansion inside it and the gas would escape. But if it were able to stand the strain without bursting one thing that is certain is that the oxygen would remain in it as a bubble. Anyone who has handled preserved specimens of Crustacea in spirit knows the difficulty of getting rid of a bubble of air in a specimen once it has got in. In my specimen F 2 there was no bubble of air, as I think my photographs (loc. cit. plate xxxii) established without a doubt.

As far as I have argued, therefore, I have shown that my specimen of *Nebaliopsis* could not have expanded as suggested by Linder merely by being relieved of the enormous pressure under which it lived, simply because liquids are almost incompressible, which is the same thing as saying unexpansible. Neither could it have become extended with gas, because there was in fact no gas in the specimen when it reached the surface. My chief argument, however, in refuting Dr Linder's suggestion is the obvious undistorted condition of specimen F 2. Naturally, when I first received the specimen I was struck with its bloated appearance, and this caused me to wonder whether it could be abnormal. Directly I examined it ventrally and dorsally, however, I had no hesitation in deciding that it must be undistorted, for it showed the complete ventral chain of nerve ganglia, and, more striking, the complete tubular heart. I am afraid I assumed that this perfection of the inner organs was so obviously a testimony to the condition of the animal that I did not comment on it in my paper; I merely relied on the photographs. Now, surely it is practically impossible for the hind part of the cephalothorax to be enlarged without producing an obvious distortion of either the nerve chain or the heart. Certainly if the supposed expansion were caused by an expanding gas bubble (and I have shown that this, however remote, is the only possibility) the expansion would not be bilaterally symmetrical, for the bubble would of necessity lodge to one side of the gut.

The final demonstration, however, that the Discovery specimen is normal comes from the words of Dr Linder himself. He states (loc. cit. p. 7) that 'a study of sections provides a certain proof...

specimens that are only slightly swollen show the muscles of the thorax torn away from the integument'. Now, specimen F 2 was sectioned down to the sagittal plain as I stated in my report (loc. cit. p. 204). The sections are quite normal and are typical of deep-sea material. There is no such distortion of the musculature as Linder predicts, or, in fact, of any other organ. The proof of this is that Miss Rowett (1943) has used the series of sections to work out with conspicuous success the anatomy of the gut.

Miss Rowett's work was published a few months after the appearance of Dr Linder's paper, and throws a completely new light on *Nebaliopsis*. Moreover, it supplies an obvious explanation of the differences between our two specimens. She showed that the large opaque mass in my specimen F 2, which I tentatively suggested was the ovary (loc. cit. p. 203), was in fact an enormous sac-like diverticulum of the mid-gut. It was filled with a *homogeneous* coagulum; that is, with a mass of food material in which there was no structure (Rowett, 1943, p. 15). From this, with admirable argument, she puts forward the view that *Nebaliopsis* is an egg-sucker. She then shows that, quite apart from the apparatus for filter-feeding, this remarkable form is fully adapted in a variety of ways to this peculiar diet. In a paper that is now in the press she has gone further and has pointed out the extraordinary correspondence that occurs between the adaptation of *Nebaliopsis* and of the nudibranch *Calma glaucoides* which is known to feed exclusively on a diet of eggs.

The adaptation which is of importance in the present discussion is the enormous mid-gut sac. Miss Rowett points out (loc. cit. p. 8) that this sac is 'without any convolution and with only a few septa arising from its walls'. Therefore while it does not provide much extra surface for its digestion it is admirably suited for a storage organ. Now eggs will certainly not always be present at the great depths at which *Nebaliopsis* lives. During the breeding periods of neighbouring animals there will be abundance, but in between whiles scarcity. However, it must be remembered that the neighbours of *Nebaliopsis* are few and far between, so that even when eggs are present they will be patchy in their distribution. A large storage organ is clearly an adaptation to this. It enables the animal to take a considerable quantity of food on the infrequent occasions when it happens to encounter a patch. My specimen F 2 is clearly a specimen that had just had a meal and it became distended in the same natural way in which, for example, a blood-sucking tick becomes bloated after a meal. Another parallel is to be found in a deep-sea fish such as *Chaismodus niger* (Murray and Hjort, 1912, p. 721, fig. 515) which has an abdomen so distensible that it can accommodate a larger specimen of the same species.

The musculature of the body appears to be arranged so as to allow the body to expand in the hinder trunk region. The abdominal region is a packed mass of muscles. The cephalic region contains all the musculature of the antennae and mouth parts and the muscles extend ventrally in association with the trunk limbs. They become less marked posteriorly in relation to the simple condition of the eighth trunk limbs. The dorsal and ventral longitudinal muscles are practically non-existent in the thoracic region. There is thus a large region of the body, the posterior and dorsal thoracic region, which is almost devoid of muscles. The integument over this region is very thin and flexible and it is here that, as my photographs show, the expansion takes place.

To summarize, the enlarged appearance of the Discovery specimen F 2 is due to the fact that it had just taken a meal. It is not in any way an unnatural distension. A comparable specimen in which the mid-gut digestive sac is empty is shown in Plate XV. This beautiful example occurs in a second small Discovery collection. I consider this specimen much more perfect than Linder's, for it shows the rostrum, eyes, and antennae in a normal position for one of the Nebaliacea.

The photograph which Linder published (loc. cit. Taf. I, fig. 1) agrees fairly closely with the sketch published by Ohlin (loc. cit. fig. 1); enough, in fact, to make it fairly certain that the sketch was made after fixation and not while the animal was swimming round. How the animal was preserved we do not know. There is nothing to indicate the use of any special fixative, and so most likely it was placed in spirit or formalin in sea water. Also it was almost certainly moribund, when it was pickled, for as Linder (loc. cit. p. 7) points out after quoting Ohlin, it could only swim on its side, a quite unnatural position. Moreover, having obtained for the first time a living specimen of a deep-sea crustacean it is only natural that the scientist would keep it alive as long as possible. Whatever happened, it was during the fixation that the first damage to the specimen occurred. Now spirit and formalin are both slow fixatives and take a considerable time to kill an organism. I have even seen a specimen of the fairy shrimp *Chirocephalus* placed in the relatively fast fixative Bouin, and after one minute it was still wriggling. During this time the outermost musculature becomes fixed, while the inner muscles still contract. Naturally the result is a distorted specimen. It looks to me as though Linder's specimen, during fixation, became distorted in this way, for in the head region the rostrum, together with the antennules and antennae, appear to have been pulled inwards so as to become completely covered by the carapace. This does not occur in any other nebaliacean. Even in badly damaged specimens of *Nebaliopsis*, in which the body has become wrenched away from the carapace, the head region appears to remain intact with the antennae and rostrum projecting beyond the edge of the carapace. This is very clearly shown in one of Linder's own specimens (loc. cit. Taf. 1, fig. 3), which shows just the same arrangement of these parts as in the photograph I am publishing in this paper as well as in that of my original F 2 specimen.

In addition to this fixation damage I think there must have been slow shrinkage of the whole body relative to the carapace after fixation, for in Ohlin's sketch the hinder margin of the carapace reached only to the front end of the seventh abdominal segment, while in Linder's photograph taken years later it stretches to the hind end.

Some deep-sea Crustacea are able to stand a journey up to the top and appear quite normal when caught; thus *Gigantocypris* is often collected in numbers from great depths and will swim about actively in bowls of sea water. My own studies of this form (Cannon, 1943) have, I think, demonstrated that these forms are quite unaffected by the enormous reduction of pressure which they undergo in their passage upwards of maybe more than a mile. *Nebaliopsis*, on the other hand, is now known from a considerable number of specimens, and yet only three are anywhere near perfect. The greater number are completely disrupted. Now *Nebaliopsis* is a much more delicate form structurally than the robust *Gigantocypris*, but I feel certain that this does not explain the difference between them. *Gigantocypris* has a firm and substantial outer shell, while that of *Nebaliopsis* is extremely delicate. But, on the other hand, both have bodies constituted of cells containing living protoplasm and, quite irrespective of their exoskeletons, that protoplasm is in equilibrium under enormous pressure. When they are brought to the surface that pressure is relatively quickly diminished. Now, there can surely be no doubt that this change will produce an immediate disturbance of the equilibrium of the protoplasm. In the majority of cases it is probable that the protoplasm would be unable to readjust itself and so would be precipitated, with inevitable death resulting. This is what I consider happens in *Nebaliopsis*. On the other hand, if the protoplasm can so adjust itself as to remain in equilibrium, then the specimen will appear living and normal at the surface as in the case of *Gigantocypris*. If my argument is correct, it means that *Nebaliopsis* collected in deep-sea trawling is normally fixed (but not preserved) soon after leaving the depth at which it occurs. It is fixed, that is, its protoplasm is precipitated, by suddenly reduced pressure. Now this will act on all parts of the body quickly at the same time. Thus, there will be no question of penetration of fixative. The protoplasm of all cells of the body, whether they are deep or superficial makes no difference, will suddenly precipitate. There will be no distorting death struggles—one part of the body still alive pulling against another part already fixed. There will be a sort of shock suddenly immobilizing all parts of the body at the same instant, and the result will be a fixed preparation as nearly like the living form as possible. If, now, such a specimen can finish the journey to the top and, more important, on to the boat, without being crushed, and further, if it is subsequently handled and preserved by an expert, such specimens as my F2 and the one I illustrate in this paper will be obtained.

THE FILTRATORY FEEDING MECHANISM

In *Nebaliopsis* I described in my earlier report (1931, p. 210) a filtratory mechanism unique amongst the Crustacea, for it was based on the joint action of the maxilla and the first trunk limb. I gave evidence that this type of filter-feeding must have evolved from that of *Nebalia*, which I had previously shown (1927) resulted from the combined action of all the trunk limbs, the maxilla being minute and taking no part in the filtering process. I suggested (1931, p. 216) that along the lines leading to *Nebaliopsis* the ancestral form 'developed the maxillary-first trunk limb filter mechanism, at first, to aid its more posterior trunk limb filter.... Then, when this became sufficiently advanced, it opened up the carapace—maybe to allow a greater inflow of water on to the maxillary region.... The maxillary filter now became the chief feeding mechanism.... As it developed so the carapace widened out and water came to be sucked in from all directions. The trunk limb filter was then almost abandoned, the trunk limbs swinging forwards to act as a subsidiary mechanism supplying water to the...maxillary-first trunk limb filter.'

Linder (loc. cit. p. 30) accepts my description of the new filter apparatus, but considers that in addition the trunk limbs together still form an efficient filtering mechanism. He even goes further (loc. cit. p. 31) and suggests that the filtering power of *Nebaliopsis* is more effective than that of *Nebalia*, a point which I most strenuously deny. The filter process of *Nebalia* is, as far as I can judge, the most efficient of all those crustacean feeding mechanisms that I have studied, for water carrying suspended food particles is sucked into a filter chamber just as if it were being sucked into a cylinder by a movable piston, and after being filtered is passed to the exterior through a valve as efficient as a rubber gas valve.

The filter chamber of *Nebalia* into which the water is sucked is the median ventral space between the trunk limbs. The entrance lies anteriorly in the mouth region. Posteriorly the chamber is closed by the eighth trunk limbs uniting medially to form a wall. Laterally the trunk limbs form its walls, the spaces between the limbs being spanned by continuous sheets of filter setae. Dorsally it is roofed by the mid-ventral body wall, while ventrally there is a complete and thick floor formed by the endopodites of the trunk limbs which recurve sharply backwards and slightly inwards so that their tops touch in the middle line. Thus the filter chamber is a simple laterally compressed space with but one entrance, and that is relatively small. It is a slit extending from the lower edge of the labrum to the 'elbow' of the first trunk limb. Now the first trunk limb is itself small—it is only about two-thirds the length of the middle trunk limbs which are the main limbs acting as pistons sucking water into the filter chamber. Thus we have a relatively large filter chamber with a small opening into it. Clearly suction will be very powerful, so that once water has been sucked in it will not escape out again through the same opening—it must remain to be filtered. Obviously then any enlargement of this entrance will lead to a diminution in the force with which the water is sucked in. In *Nebaliopsis* the whole floor of the filter chamber has opened up by the disappearance of the long recurved posteriorly projecting endopodites of *Nebalia*. Hence, even if the trunk limbs were acting as in the latter form, the suction into the filter chamber would be relatively weak. However, it is wrong to call this median space between the trunk limbs of *Nebaliopsis* the filter chamber. Apart from the fact that I showed that another filter chamber had developed between the maxilla and the first trunk limb, this space, now that it is completely open ventrally, is directly comparable with the mid-ventral space of a branchiopod. Thus, again supposing that the trunk limbs were still filters, as they are in *Nebalia*, the efficiency of their combined efforts in

Nebaliopsis would be comparable with that of the feeding mechanism of the fairy shrimp *Chirocephalus*. Now this type of filtratory mechanism is not nearly so powerful as that of *Nebalia*. A floating particle, once it has been sucked in between the limbs of *Nebalia*, cannot, as far as I can see, escape unless it is forcibly ejected. On the other hand, a particle, on being sucked into the mid-ventral space of *Chirocephalus*, as often as not is blown out again, and it would be the same with *Nebaliopsis*.

However, this is all on the supposition that the trunk limbs of *Nebaliopsis* are still efficient filters. But I pointed out (1931, p. 211) that this cannot be so because, among other things, their lateral parts do not form a valvular system as they do, in fact, in all other Nebaliacea. In *Nebalia* and *Paranebalia* it is the epipodites together with the exopodites, and in *Nebaliella*, where the epipodites are absent, the exopodites alone, which project backwards and completely and accurately span the gaps between successive limbs, thus preventing any lateral entry of water into the inter-limb spaces during the suction phase. In *Nebaliopsis*, on the contrary, there are wide lateral gaps both proximal and distal to the epipodite through which water could pass unhindered. Linder (loc. cit. p. 30) denies this and says that the gaps are simply due to the distension of the limbs. He implies, although he does not say so in as many words, that the main axis of the limb has elongated under pressure, while the epipodite has remained the same size, and hence a gap has occurred between the epipodite and the body wall. The fallacy of this is obvious. There is no reason why the epipodite should not enlarge along with the rest of the limb. In fact from the anatomy of the limb it is fairly certain that if this hypothetical swelling did take place it would be the epipodite which would enlarge most and not the main axis of the limb, for the latter is skeletally relatively rigid, while the epipodite is extremely delicate.

One further argument: if the lateral gaps which are so clearly seen in the upper photograph of my plate xxxii (1931) are due to artefacts, how is it that the lateral space between the first and second trunk limbs is so accurately covered by the epipodite of the first trunk limb (loc. cit. p. 206, fig. 3)? Is this also due to distension? Surely not—it is simply a manifestation of suction between the first and second trunk limbs which is absent, or practically so, between the other limbs.

Having explained away the lateral gaps between the trunk limbs, Linder still has to deal with the distal gaps that occur between the tips of the limbs. These gaps result from the absence of the posteriorly curved endopodites. The typical trunk limbs 'are unsegmented, the exopodites being represented by a slight protuberance.... The endopodite must be considered as the tip of the limb distal to this exopodite lobe' (Cannon, 1931, p. 207). They are, as Linder correctly states (loc. cit. p. 10), turgor limbs, that is, limbs that depend for their rigidity on an internal blood pressure. Moreover, 'the distal two-thirds of each limb is devoid of musculature' (Cannon, loc. cit. p. 210), so that the limb cannot be bent by internal muscles—it can only be moved as a whole by the muscles at its base after being made rigid by being pumped full of blood.

Now Linder explains the closure of the gaps between the tips of the limbs during the 'Abduktionsphase' (suction phase) as due to a bending over of one limb on to the limb in front, as a result of suction between the limbs (loc. cit. p. 30). This would imply that directly any two successive limbs commence their suction stroke, the suction between them becomes so great that it causes the hind limb to bend in the middle so that its tip comes down on the limb in front and closes the distal gap. But what causes this original powerful suction? Unless there are efficient valves, the suction between the limbs will be negligible. The gap is there to start with and hence the small suction caused by the inter-limb space enlarging will simply draw in water through the gap which will at once neutralise the suction. Linder says that similar conditions obtain in the *Anostraca* (loc. cit. p. 30) and he sees no reason why the same thing should not happen in *Nebaliopsis*. But things are quite different in the *Anostraca*. There the limb is jointed and the distal endopodite flap is provided with a complete set of muscles by which it can be pulled down and held, if necessary, on to the next limb.

Linder goes further and, as I have mentioned above, states (loc. cit. p. 31) that the filtering mechanism of *Nebaliopsis* is an even more efficient system than that of *Nebalia*. He points out that it differs in two respects—first that the eighth trunk limb is not filtratory, and secondly that the maxilla, together with the first and second trunk limbs, form a separate filter system. It can only be deduced from this that Linder considers that the *Nebaliopsis* mechanism evolved directly from that of *Nebalia*, a fact with which all will agree, and further, that it only shows the two differences which he enumerates. There is, however, another fundamental difference which he has overlooked. In *Nebalia* the trunk limbs curve backwards so that one limb overlaps the limb *behind*. In *Nebaliopsis*, according to Linder's hypothesis, the limbs bend forwards so that one limb overlaps the limb *in front*. This being so it is clear that Linder's *Nebaliopsis* mechanism could not have evolved from that of *Nebalia*, for such an evolutionary process would involve an intermediate stage when the limbs curved neither backwards nor forwards and so would be unable to carry out any filtration. If, therefore, the trunk limbs of *Nebaliopsis* do filter according to Linder's mechanism, then this would be an entirely new development and this is not what Linder has been arguing.

There would be the same difficulty here as occurs when it is attempted to derive the malacostracan maxillary filter from the anostracan trunk limb filter (Cannon, 1928, p. 820). Both these are based on typical phyllopodia, but in the former the limb is concave anteriorly and in the latter posteriorly. But what is more important, the functional activities of the limbs are dependent absolutely on these arrangements of the limbs. The same applies to *Nebaliopsis* and *Nebalia*. The activities of their trunk limbs, whether actually filtratory or only supposedly so, depend on their arrangement and since they are arranged as mirror images, one pointing forwards and the other backwards, it is not possible to derive one mechanism from another, without postulating an intermediate stage during which the limbs could not function.

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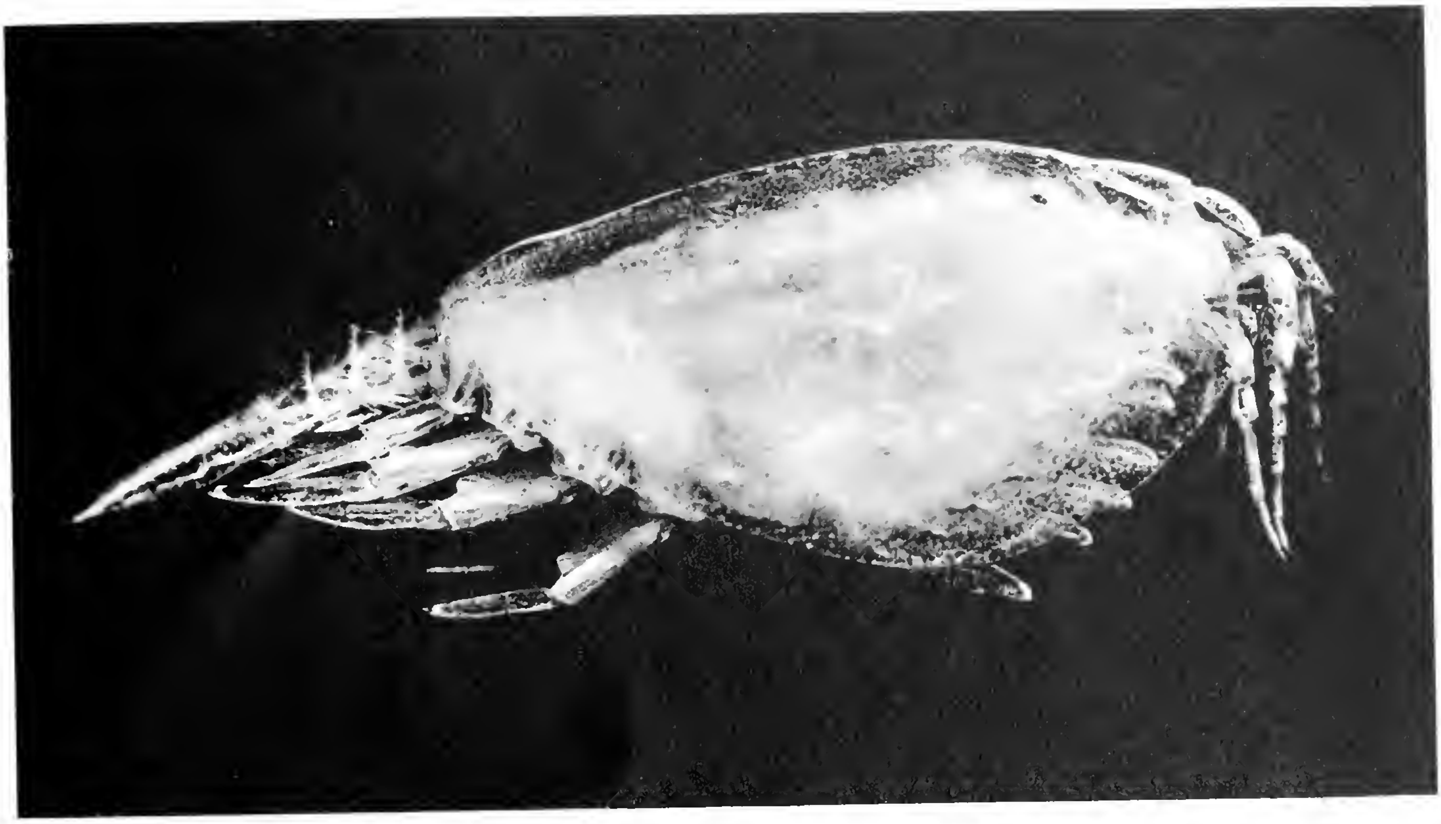
PLATE XV

Nebaliopsis typica ×9. St. 1636. Date 30. xi–1. xii. 35. Net N 100 B. Depth 380–150 m.



NEBALIOPSIS TYPICA

[*Discovery Reports. Vol. XXIII, pp.* 223–408, *Plate XVI, December* 1946]

REPORT ON TRAWLING SURVEYS ON THE PATAGONIAN CONTINENTAL SHELF

Compiled mainly from manuscripts left by the late E. R. Gunther, M.A.

BY

T. JOHN HART, D.Sc.

WOODS HOLE, MASS.

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FOREWORD

By N. A. Mackintosh

The position, extent, and physical features of the Patagonian Continental Shelf are such as to prompt comparison with the major fishing grounds of the northern hemisphere; but prior to the trawling surveys of the R.R.S. 'William Scoresby' the nature and magnitude of the population of demersal fishes on the shelf had not been explored. Three surveys were carried out, for the most part at different times of the year, in 1927, 1928 and 1931–2; and the principal results are set forth in Dr Hart's report.

The report is based to a considerable extent on the unfinished work of the late Mr E. R. Gunther, and the circumstances in which it was prepared require a word of explanation. Several members of the Committee's staff took part in the work at sea, but the largest part was played by Mr Gunther, and he was in charge during the third and most extensive survey. It is very largely owing to his untiring energy and enthusiasm, and his broad conception of the problems involved, that a most comprehensive and thorough investigation was carried out. The surveys have resulted in a very great mass of data, and the preparation of a general report on the results was undertaken by Mr Gunther. Some delay in the completion of this report was inevitable. A taxonomic account of the fish fauna, and a description of the marine deposits of the shelf, were needed first, and these have already been published in the *Discovery Reports*, together with systematic papers on certain invertebrate groups. In the years before the war, however, Mr Gunther had made good progress with the general analysis of the material, though his work was unavoidably interrupted from time to time by other responsibilities. Since he held a commission in the Territorials he was called upon for military service just before the outbreak of war, and further progress was therefore suspended. His death on active service in 1940 was a severe loss to the Discovery Investigations.

Owing to the dispersal of the Committee's staff in wartime no more could be done until 1943, when Dr Hart was able to take over the work. The task of picking up the threads and collating the data naturally involved considerable difficulties; and for many aspects of the subject it was necessary to start again from the original data. The substance of the report can be regarded as the combined work of Mr Gunther and Dr Hart, but the latter, as he explains below, has written the entire text in its final form.

It will be realized that this report deals mainly with the general biology and ecology of the demersal fish, and with the prospects of commercial trawling. The surveys were planned for this purpose and did not include an investigation of the pelagic fish such as the Falkland herring. Various references to these fish are included in the report, but there is still little information on the prospects of commercial fishing by other means than trawling. The principal conclusion of the report is that hake, and some other edible species, are obtainable in moderate numbers by trawling. Although the shelf has been found to be less rich in trawlable fish than might have been expected, it is possible that enough could be taken to support an industry if markets could be found, and problems of preservation and delivery could be overcome. The report may be regarded as a contribution to our knowledge of the fish faunas of the world, and it is hoped that it will be of assistance in any consideration of the future economic development of the Falkland Islands.

REPORT ON TRAWLING SURVEYS ON THE PATAGONIAN CONTINENTAL SHELF

Compiled mainly from manuscripts left by the late E. R. Gunther, M.A.

By T. John Hart, D.Sc.

(Text-figs. 1–53, Plate XVI)

INTRODUCTION

THE Patagonian Continental Shelf extends from the River Plate in the north to Staten Island in the south, and from the South American coast to an average distance of some 250 miles offshore to the eastward. Outlying areas with depths of less than 200 m. extend round the Falkland Islands and on the Burdwood Bank to the south. Beyond the 200 m. contour, which may be taken as the edge of the shelf, the descent to oceanic depths is more or less abrupt. Faunistic writers referring to the Patagonian region commonly include the Magellan Channels and the coast of southern Chile in their geographical unit, but there is no need to qualify our definition of the Patagonian Continental Shelf so as to exclude the west coast, for there the descent to oceanic depths is so immediate that a shelf (in the accepted meaning of the term) can scarcely be said to exist. The investigations to be described here covered the whole of the shelf south of lat. 42° S., an area of some 150,000 square miles which is larger than the entire North Sea. Except for descriptions of small collections made in coastal waters, the marine fauna of the region was almost unknown when the Discovery Investigations began, although it constitutes the largest expanse of shoal water (accessible to trawling) in the 'cold temperate' or sub-Antarctic Zone of the southern hemisphere.

The need for a fisheries survey of the shelf, to gain information on the prospects of developing a commercial fishery from the Falkland Islands, was recognized from the outset of the Discovery Committee's work (Kemp, in Kemp, Hardy and Mackintosh, 1929, p. 148). The greater urgency of problems relating to whaling and sealing in the more southerly (Antarctic) waters of the Falkland Islands Dependencies limited the scope of the trawling surveys however, and combined, with Mr E. R. Gunther's untimely death in 1940, to prevent publication of results until now. Vast collections of benthos, with lesser but probably representative collections of plankton and hydrological data, were obtained. Gunther had hoped to use the information gained from these, as they were worked up by various specialists, in presenting the ecological study of the fish fauna in much greater detail than can now be attempted. Continued work on many of the groups may not be possible for years, but by great good fortune the taxonomic revision of the fishes had been completed by the late Mr J. R. Norman in 1937. As the need for more knowledge of the bionomics of the fish fauna became urgent, Dr Mackintosh asked me to prepare this report, working from Gunther's manuscripts. I found this unusually difficult because for the first time in my experience it involved work upon data which I had not helped to collect. Moreover, Gunther had planned the production of five separate papers, and the manuscripts were in widely different stages of incompleteness. As a single report was called for I have entirely re-written the text myself, retaining Gunther's leading ideas and indicating our indebtedness to him so far as I am able. I found it necessary to recalculate all numerical data, using the original log books, except where the reasons for alterations made by Gunther himself could be traced. Any mistakes in this part of the work are my own responsibility. Both Mr Gunther and I have gained much from discussion of hydrological results with Dr G. E. R. Deacon, F.R.S., and the brief notes on the hydrology of the region presented here owe much to him.

My own experience of trawling in the southern hemisphere has been limited to a few experimental hauls off the Falkland Islands and off the south-west coast of Africa, but I have seen enough to recognize the tremendous amount of hard work in the field that these trawling surveys must have entailed. This is especially true of the last and most comprehensive of the surveys, when Mr Gunther was in charge of the scientific work and had as his assistant Mr (now Comdr) G. W. Rayner. I think this survey was one of the most arduous pieces of field-work ever completed by the Discovery Investigations; and, as my two colleagues were always anxious to point out, its success was largely due to the able and willing co-operation of the Captain, net-man and ship's company.

The work of writing up the report has been carried out in the Laboratory of the Marine Biological Association at Plymouth, by courtesy of the Director, the late Dr S. W. Kemp, F.R.S., who, while Director of Research to the Discovery Investigations, planned much of the work here described. Dr Kemp's personal kindness and encouragement have helped me throughout my working life, and I am sure all members of the Discovery scientific staff would wish to say the same. I have gained much from the advice and encouragement of the staff of the Laboratory and more especially from hints on the handling of numerical data by Mr E. Ford and Mr G. M. Spooner. Had these two gentlemen not been away on war service during most of the period my task would have been lighter. The rapidity with which the librarian, Miss M. Sexton, procured obscure references under all the difficulties of wartime conditions was a great help. I have gained much from an all-too-brief interview with Mr C. F. Hickling of the Ministry of Agriculture and Fisheries (now Fisheries Advisor to the Colonial Office), who also helped with the loan of some of his important papers on Hake. This brings me to a point that needs emphasis if the work described here is to be justly appreciated—it was planned and carried out before the results of the last decade of fishery research, prior to the war, were known. If, for example, the final results of Hickling's prolonged work on European Hake had been available there is no doubt that our programme could have been modified with advantage, but our data were collected before Hickling's work was complete.

FIELD METHODS AND PRELIMINARY OBSERVATIONS

The three trawling surveys were carried out by the R.R.S. 'William Scoresby' in autumn (March–April) 1927, winter (June–July) 1928, and throughout the whole of the warmer half of the year 1931–2 (October–April). A few additional observations were made within the area by the R.R.S. 'Discovery' and by the R.R.S. 'Discovery II'. A description of the ship and of the gear will be found in Kemp, Hardy and Mackintosh (1929). In the more detailed parts of this report abbreviated descriptions of the gear have been used, as standardized throughout the station lists in *Discovery Reports*. Meanings of the abbreviations relevant to the present work are repeated here for the convenience of the reader.

For this study of the bionomics of the fish fauna, the gear may be grouped under two main headings: 'Trawl + accessory nets' and 'Other gear'.

'Trawl + accessory nets' comprises:

OTC	Commercial otter trawl, 80 ft. headline, 3 in. cod-end mesh.	
N7-T	Net 7 mm. mesh	Fine-meshed nets attached to the back of the trawl as described in the work mentioned above.
N4-T	Net 4 mm. mesh	
NCS-T	Coarse silk net	

'Other gear' includes a motley collection of apparatus that helped to extend our knowledge of the distribution of the fish fauna in lesser ways. (The finer plankton nets, which scarcely ever catch fish except in their larval stages, and hydrological apparatus are not considered here.)

OTL	Large otter trawl, 40 ft. headline, 1¼ in. cod-end mesh.	
BTS	Small beam trawl.	
NRL	Large rectangular net.	
BNR	Russell's bottom net.	
DC	Conical dredge.	
N450H	Large plankton net 4½ m. diameter at mouth.	
TYF	Young fish trawl, stramin, 2 m. diameter ring	Fished either horizontally (H) or obliquely (B).
N100H (or B)	Plankton net 1 m. diameter at mouth	
NH	Hand net.	
LH	Hand line.	

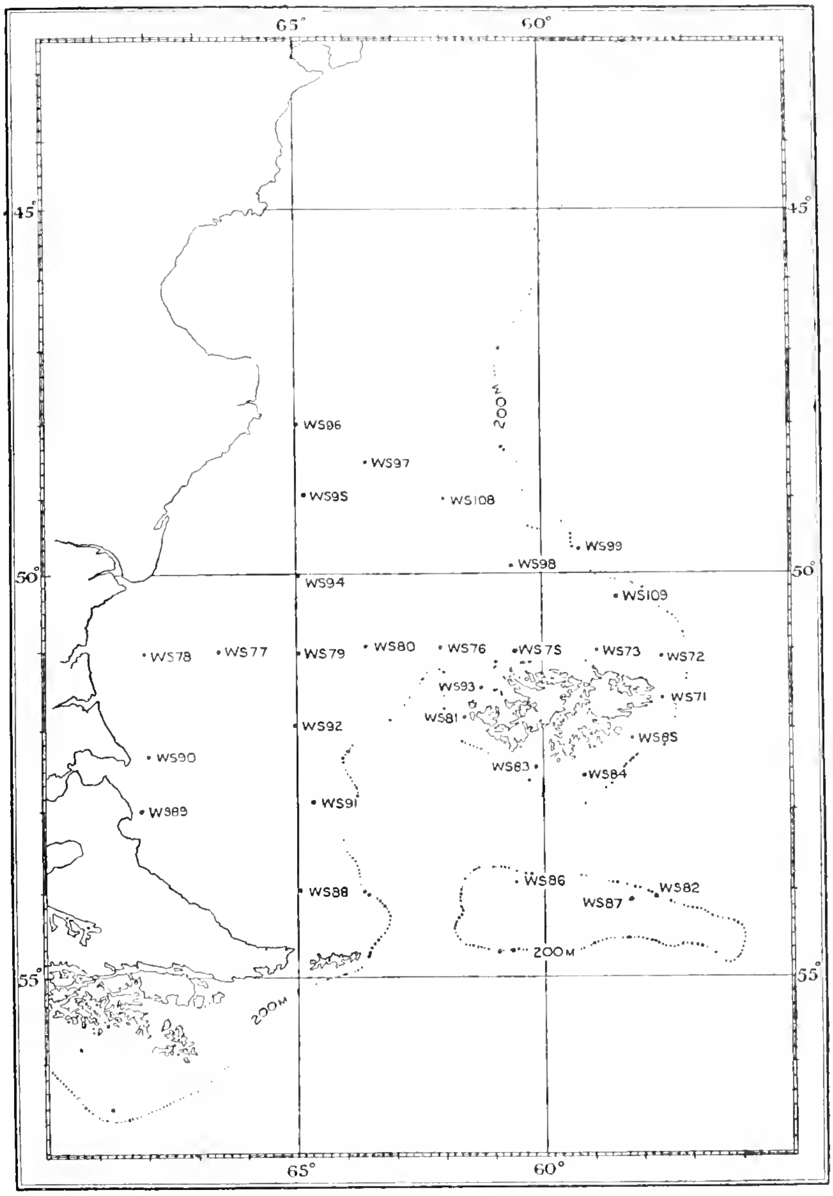

Fig. 1 *a*. First trawling survey; station positions in March and April 1927.

This report is primarily based upon the hauls of the trawl + accessory nets, and full details of date, time, position etc. of all such hauls (apart from total failures) are tabulated in Appendix I. Similar details regarding the working of all the other gear will be found in our Station Lists when completed. For the present purpose reference to other gear has only been made where it directly affects our knowledge of fish distribution.

THE FIRST SURVEY

The first survey was aimed at investigating the area immediately surrounding the Falkland Islands, with some observations on the shelf between them and the mainland, and on the Burdwood Bank. Dr N. A. Mackintosh, now director of research to the Discovery Investigations, was in charge of the scientific work. With him were Mr E. R. Gunther specializing on the fishes, and Mr D. Dilwyn John working on the invertebrates and the food and parasites of the fish. The normal routine at the trawling stations was: first, a sounding; then a haul with the conical dredge; then, unless the bottom had proved impossibly rough, an hour's haul with the 'trawl + accessory nets'. The trawling was followed by a second sounding, and the collection of water samples from surface and bottom for the determination of temperature and salinity. A line of full hydrological and plankton stations between the Jason Islands and Port Desire was also worked, so that with incidental stations elsewhere and minor digressions to land the fur seal guard on Elephant Jason, and to mend nets, much work was accomplished in the period of just over two months devoted to the survey.

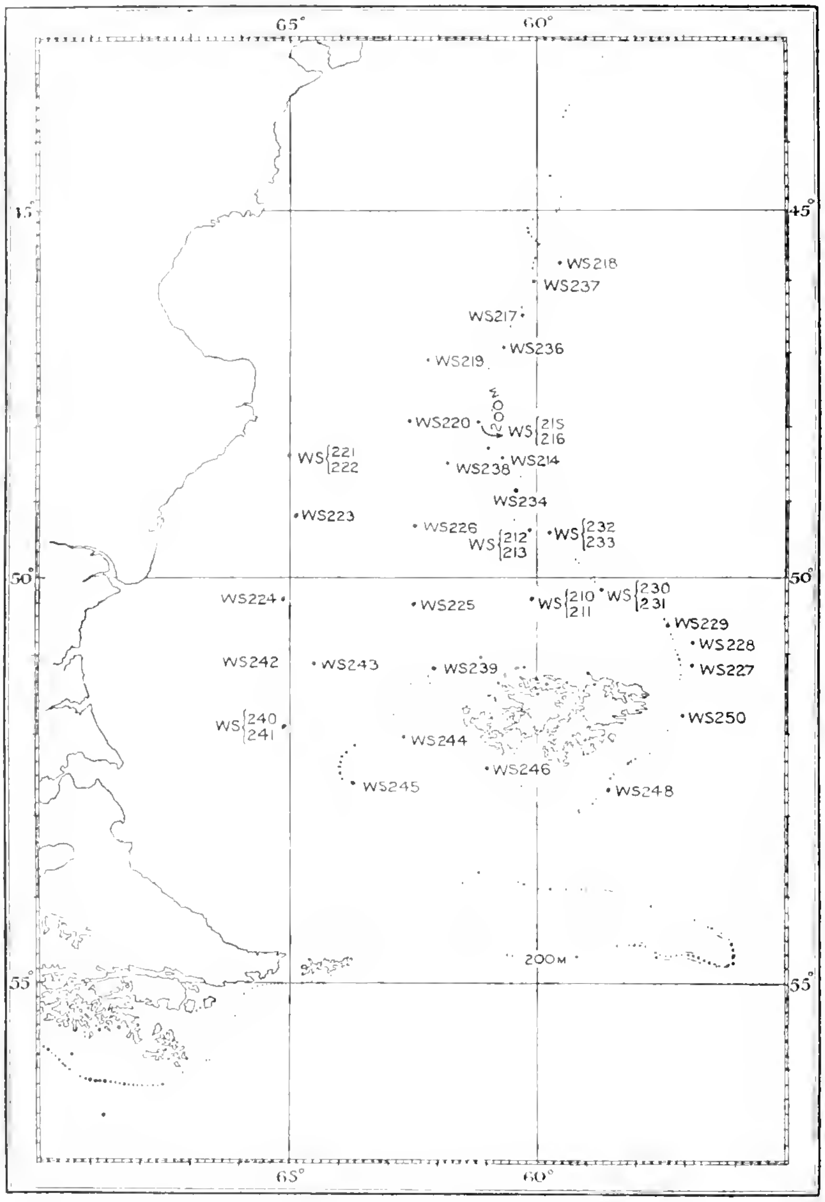

Fig. 1*b*. Second trawling survey; station positions in June and July 1928.

The species of fish were counted, and the important ones measured and sexed, and data on the stages of maturity at different lengths collected. Occasionally observations on scales, gonads, and pathological growths, and sexing of the less important species were possible. Provisional identifications proved adequate for the subsequent accurate determination of almost all the specimens taken, in spite of the facts that it was only possible to preserve a small proportion of the catch, and that some Nototheniidae and Rajidae presented special difficulties which were only cleared up in the course of the preparation of Norman's report years afterwards.

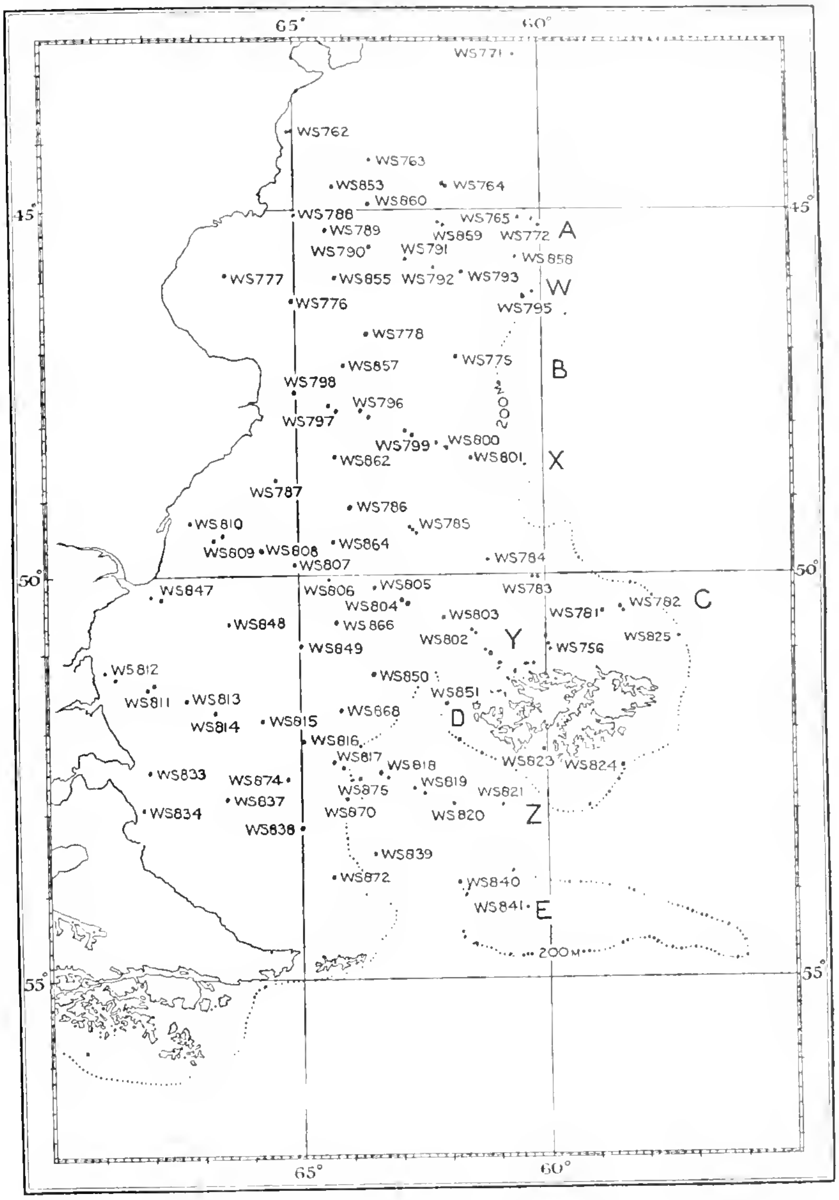

Fig. 1*c*. Third trawling survey; station positions October to April 1931–2.

The invertebrates were more difficult owing to the great bulk of many of the catches. Quantities of previously preserved species were estimated and noted when possible, and all or a noted proportion of the others preserved; but the bulk of the catch and masses of broken sponges, coralline polyzoa, large Scyphomedusae, etc., frequently made it impossible to sort the catch adequately in the limited time available.

Some forty species of fish were taken, and it was reckoned that the most important were:

Squalus lebruni
Psammobatis spp.
Rajidae (several spp.)
Clupea fuegensis
Macruronus magellanicus
Merluccius hubbsi
Salilota australis
Cottoperca gobio
Notothenia ramsayi
N. guntheri
Champsocephalus esox
Stromateus maculatus[1]

The existence of overlapping characters in the '*tesselata* group' of *Notothenia* was noted in the field, also the profuse variation among the Rajidae of the locality, which necessitated a large collection for further revision. Five teleosts new to science were collected, and specimens of *Cottoperca gobio* and *Dissostichus eleginoides* much larger than any previously recorded were obtained.

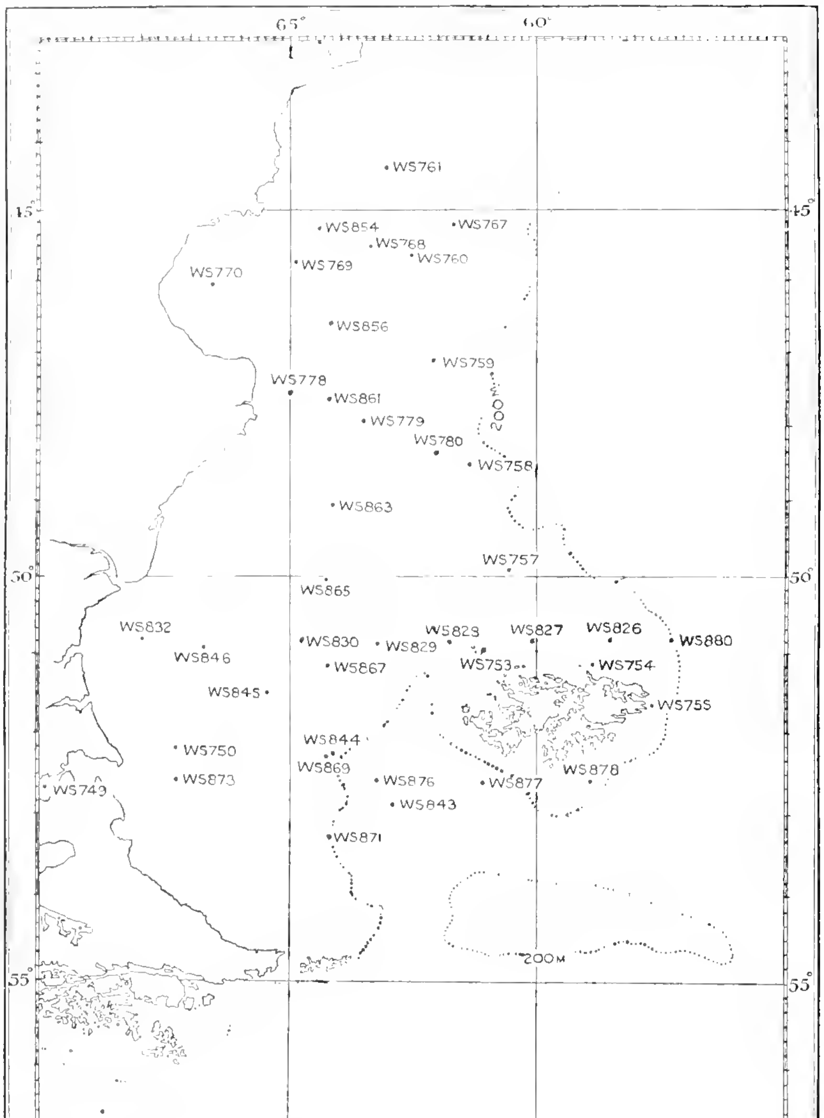

Fig. 1*d*. Plankton and hydrological observations; station positions 1931–2.

The most important result of the survey was to demonstrate that hake (*Merluccius hubbsi*) were to be found in moderate quantity on the shelf to the north and west of the Falkland Islands. This fish was for long confused with *Merluccius gayi*, the west coast species, and was the object of several small

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[1] The names in this list are those determined after Norman's revision.

trawling ventures from the great ports of Montevideo and Buenos Aires. These all worked very much farther to the northward and close in to the land; it is safe to say that no considerable haul of the species had been taken south of lat. 42° S before. On this autumnal survey the hake were distributed over the shelf to the north of a line from Cape San Sebastian to the northernmost of the Falkland Islands (Figs. 1*a*, 2). The largest catches were obtained north-west of the Falkland Islands, but there was little evidence of any special concentration there. A moderately rich haul was obtained so far away as St. WS90 near Magellan Straits. Females were commoner than males, males were commonest in the shallower water along with the smaller females, and the catches with the largest females were almost devoid of males.

Notothenia spp. were the most widely distributed and most numerous fishes, but were obviously less important than hake owing to their small size. A very heavy catch of *Notothenia* was obtained at one station north-west of the Falkland Islands, and another on the Burdwood Bank.

Macruronus magellanicus was most frequent at hauls made in the centre of the plain of the shelf. Its excellent edible qualities and freedom from superfluity of small bones were gratefully recorded. *Stromateus maculatus* was commonest near the mainland, but was also found at two offshore stations towards the end of the survey. The flesh of this species was described as resembling that of the herring, but not quite so good. It was remarked of both these species that though not very abundant they occurred along with hake and might serve to supplement catches of the latter.

John's observations on the food of fishes showed that squids, *Clupea* spp., *Thysanopsetta naresi*, hyperid amphipods and small Euphausiidae formed the bulk of the hake food. Each predominated in different hauls to the exclusion of some or all of the others. The fact that hake snatch up food while in the trawl was noted. This habit is also common among European hake, a point that became well known with the publication of Hickling's work later. The stomach contents of small numbers of other less important species of fish were recorded, and John also collected large numbers of fish parasites.

Invertebrates formed the bulk of the nine catches made within 20 miles of the Falkland Islands in depths of 80–130 m., where fish were scarce. Sponges, actinians, Alcyonaria, coralline Polyzoa, spider crabs, echinoderms and ascidians were extraordinarily abundant. These invertebrate hauls were heaviest to the south-east, south and west of the Falkland Islands. Smaller invertebrates reached their greatest abundance where coralline Polyzoa or Alcyonaria predominated. This ground was too rough for profitable trawling, owing chiefly to the corallines, large catches of 'rubbish' and few fish. This disappointing negative result must be regarded as the second important point proved during the first survey.

Invertebrates were somewhat less numerous between the Falkland Islands and the mainland, but some very heavy catches were obtained. In general the bulk of invertebrates decreased to the westward and was least near the Argentine coast. Of nektonic forms squids were taken at nineteen out of twenty-nine stations, sometimes in considerable numbers. They form an important part of the diet of the larger fishes, birds and seals, of the area. Large Scyphomedusae were taken at seventeen stations, and sometimes completely smothered the rest of the catch.

A broad tentative correlation between the nature of the bottom and possible fishing prospects was ventured upon at the close of the survey, and may be summarized as follows. On the shelf and to the north of the Falkland Islands a dark greenish brown sand predominated on fairly clean ground. This was the best ground for hake also and is therefore by far the most promising area. To the south-east, south and west of the Falkland Islands, on the Burdwood Bank and at St. WS88, a similar sand mixed with a high proportion of shell fragments occurred. This was associated with a rich invertebrate fauna and few fish, except perhaps *Notothenia* spp. The Burdwood Bank presents very poor prospects owing to foul ground and prevalent gales with a steep breaking sea. Subsequent work substantiates these pronouncements in greater detail.

THE SECOND SURVEY

The second trawling survey was carried out in the winter (June and July, 1928). Mr D. Dilwyn John was in charge of the scientific work and was assisted by Mr J. W. S. Marr. This survey was planned as a continuation of the first, with additional observations designed to discover the conditions to be found along the edge of the shelf in depths below 200 m. Routine methods at the trawling stations were the same as those followed during the first survey, with the addition of extra water sampling before as well as after the trawling. At this time the ship was (unavoidably) without an experienced trawler hand, and Mr John remarked that this led to much difficulty until the necessary experience was acquired. Much foul ground was encountered so that much time was spent in mending nets. The weather was often atrocious, and some minor breakdowns hindered operations still further, so that the ship did well to complete a rather larger programme than before (Fig. 1 *b*) in about the same time. Material was dealt with as in 1927, and a large representative collection of bottom samples and of the fauna was made.

On this survey the numbers of hake taken were small (1071 in all) and good hauls few, but it is probable that they were present nearby in greater abundance, as the following considerations show. The best catches were obtained on the edge of the shelf in depths of 200–300 m., on a line running north to a point some 300 miles north of the Falkland Islands. Later the same area was disappointing. The bottom was of clean, fine, dark green sand. On the coarse brown sand, pebbles, and shells, of the shallower waters of the shelf, very few hake were taken in the north, and fewer or none to the south. In the trough of relatively deep water to the west of the Falkland Islands, two very moderate catches were obtained. No hake were taken on the shelly bottom with heavy invertebrate fauna to the south and south-west of the Falkland Islands.

Comparing these results with those of the previous autumnal survey, when most hake had been captured on the shelf to the north and west of the Falkland Islands, it was seen that the different distribution observed in winter would agree with an offshore migration. Such a seasonal movement, connected with the sexual rhythm, was already known to occur in the closely allied European species, and by analogy John concluded that the Patagonian hake were summer spawners also. The data on condition of the gonads, though not entirely satisfactory, were compatible with such a view. The comparatively good catches in shallower water of March and April 1927 would thus be accounted for by closer proximity to the spawning season, and the poor hauls of June and July 1928 mainly by fishing 'out of season'.

It was known that European hake were caught most readily when concentrated for spawning in relatively shallow water, and that deep-sea trawlers from British ports followed the 'seasons' southwards, sometimes as far as the Moroccan coast. Also some of the British boats were already working 'over the edge', in far deeper water than any in which large-scale trawling had previously been carried out, in order to keep the market going during the off-season. Hence John's decision to work extra stations along the edge of the shelf. The fact that these were only moderately successful was almost certainly due to the steepness of the slope (far greater than that off the west coast of the British Isles) which left a very small area of moderately deep water in which fishing was possible. John concluded that a commercial fishery would have to follow the spawning fish throughout the year, and that that would mean going farther afield to the northward than the first two surveys had proceeded. Subsequent work fully substantiates this view.

The most important result of the second survey lay in this recognition of the fact that Patagonian hake would be found to move with the seasons in much the same way as their better known European relatives (allowing for the reversal of the seasons in the southern hemisphere).

Apart from the direct distributional study, the sex, lengths and maturity stages of all hake captured were recorded. The great difficulty of recognizing clear-cut stages in the development of the ovaries of these fish first became apparent at this point. The difficulty of standardizing such observations on this subject as are possible by direct inspection remained a handicap throughout. Probably it can only be tackled by large collections for subsequent microscopic examination such as Hickling (1930*b*, 1935*b*) developed during his prolonged work on the European species. Hickling found it possible to distinguish major stages by naked-eye appearance, but our observers agreed that this was never satisfactory with females of the Patagonian species. These are only slightly smaller than the European fish, but they often mature when considerably smaller, with a consequent increase in the amount of overlapping of ovarian developmental stages among fish of the same length class. Hickling was working upon a single species, but a limited staff investigating virgin ground could not make a large enough systematic collection of ovaries without neglecting other essential work.

On the winter survey female hake were markedly more numerous than male. As in the autumn the males were associated with the smaller females, and very few males were taken where large females preponderated. The majority of the smaller females were immature. Very few of the large females were ripening, and the majority seemed to be 'spent'. Among males the proportion of immature to mature fish was roughly 3 : 2. Very few were 'ripe and running'.

The hake were found to be feeding very largely upon Euphausiidae, *Clupea fuegensis*, *Notothenia* spp. and squids. Apart from hake, no fish were taken in such quantity as to be considered of possible commercial importance. *Notothenia ramsayi* were fewer than on the autumnal survey, and the best catches were taken on the same grounds as the hake. All were measured and sexed. There was a marked preponderance of females. *Cottoperca gobio* seemed to favour the rich invertebrate area to the south of the Falkland Islands, but was found elsewhere as well.

Some seven or eight species of Rajidae were observed, *Raja brachyurops* being the commonest. Very full notes on the large range of variation to be found among the members of this group were made. These were of great value later, when our data were brought into line with Norman's revised taxonomy of the Patagonian species. *Salilota australis* was taken quite frequently (fifteen stations), mostly in the more northerly part of the area, but in small numbers. Specimens of three species of rays and two species of Zoarcidae, all new to science, were obtained during the second survey.

Three well-defined associations of invertebrates were observed, correlated with three types of bottom deposit. Along the edge of the shelf north of the Falkland Islands to 45° S a fine green sand giving a clean bottom for trawling was prevalent in depths of 150–300 m. This ground was very rich in the smaller invertebrates—small ophiuroids, echinoids, other echinoderms, *Serolis*, amphipods, cumaceans and ostracods. Small quantities of *Cephalodiscus* occurred at seven of these stations. The Falkland trough yielded similar results but without the vast numbers of small ophiuroids, in slightly greater depths of water. Both these grounds yielded bigger quantities of hake and of rays than the other areas worked during the winter.

On the continental shelf to the north, west and south-west of the Falkland Islands there was darker, coarser sand, often brown, with pebbles and shells. Some patches were heavy with large invertebrates such as sponges and molgulids, and others comparatively clean. The invertebrates were heaviest close in to the Falkland Islands, and especially to the west of the Jason Islands.

The coastal waters to the south-west, south and south-east of the Falkland Islands again showed a strikingly rich invertebrate fauna of sponges, hydroids, coralline hydroids, Alcyonaria and Polyzoa. This sheltered a rich fauna of smaller invertebrates: holothurians (especially *Synapta*), polychaetes and small Crustacea. Here the bottom was of light green sand with pebbles, shells (many of pectens), large stones and boulders. It was found that this area extended over the 200 m. line for some distance beyond the immediate coastal shelf investigated during the previous survey.

Mr John concluded his preliminary report (which has not been published) with the statement that Mr Marr emphatically agreed with his opinion that 'any decision on a commercial fishery in and near the waters of the Falkland Islands must depend on a greater knowledge of the seasonal variations of the hake of the locality, and of waters farther north, and a full knowledge of what is known concerning hake in other waters'.

The preliminary results of the first two surveys have been treated at some length to show how great was their value when the third survey was planned. Several of the pioneers (notably Mr John) were engaged upon other studies after finishing their share of the field work, and the value of their efforts should be recognized. The third, most extensive and important survey, was carried out by Gunther himself with the assistance of Mr G. W. Rayner. The results form a large part of the main substance of this report. In this section, therefore, I have referred to the field observations only where they modified the general picture previously gained of the conditions. The longer period available, and increased experience, permitted improvements in working methods which must first be made clear.

THE THIRD SURVEY

At Dr Kemp's suggestion the plan of the third survey was designed to include five lines of stations spaced at regular intervals over the shelf between 44 and 54° S. Rough ground was to be avoided when possible, but efforts made to keep the stations uniformly spaced. Each line was planned on a course of 111°—roughly normal to the coast. The isotherms here run almost parallel to the coast, and the value of observations upon temperature and salinity is much increased if they can be made as nearly as possible at right angles to the isotherms, as our hydrologists have frequently pointed out. After the two northernmost lines of stations had been completed, permission was obtained still further to extend the scope of the survey. Gunther did this by interpolating four lines of more closely spaced trawling stations, and by making many additional observations, including a north-south line that provided valuable evidence of the effect of latitude. This tends to be masked (in the absence of such evidence) by seasonal movements, the effects of increased depth, and so forth.

As finally carried out the programme included vertical hauls of the Gran international net (N 50 V) with water samples from surface and bottom at all stations. The vertical nets provide evidence on the distribution of fish eggs and phytoplankton, the water samples gave temperatures and salinity determinations. The trawling stations were of three types:

(1) On the lines A, B, C, D and E (those of the original plan) the stations were 60 miles apart and the procedure the same as on previous surveys, with the addition of the N 50 V.

(2) On the intermediate lines W, X, Y and Z, the stations were 30 miles apart, and in addition to the normal routine the trawl was shot for a further period of four hours whenever fish seemed plentiful.

(3) On the additional lines the trawl was shot for one hour at stations 60 miles apart, the conical dredge was not used and no repeat hauls were made (see Figs. 1 *c*, *d*).

Russell's bottom-net, with plankton nets towed obliquely on the same wire, was fished on six rather irregular lines during passages to and from the trawling stations, and on two more lines of additional observations where a small beam trawl was also used.

The observations made included some important additions to the standard practice of the first two surveys. Among the essential routine observations the sorted fish were weighed in addition to being sexed and measured, and the larger species of invertebrates were also weighed in addition to being counted and listed. At selected stations whenever possible the important fishes, after being sexed and measured, were sorted into length groups for weighing. Notes on maturity stages of ovaries, stomach contents and parasites of fishes were made as before. In addition, an attempt was made to assemble collections of scales and otoliths from prescribed length groups of *Merluccius* and *Macruronus*. Unfortunately, it has not yet been possible to work them out. It is known that they were too small to provide conclusive evidence as to growth rate, but they will give a clue which may help to clarify conclusions drawn from other lines of inquiry that must still be regarded as tentative.

A series of carapace-breadth and weight records of the centolla crab, *Lithodes antarcticus*, were kept. These also await examination. Some biometric data on squids (body lengths and weights) were recorded, and a lot of data on the numbers, size, sex and incidence of bopyrid parasitism of *Munida* spp. These have been utilized by Rayner (1935) in an important study of the growth of these Crustacea. In their pelagic stage they are predominant among macroplankton animals of the more coastal waters of the area (in due season), a fact observed by the earliest navigators of these waters (see also Matthews, 1932). *Munida* spp. are important as food for fishes, birds and whales.

The much greater scope of the third survey, especially in more northerly parts of the area, led naturally to more and different kinds of fishes being met with. To the north such forms as *Callorhynchus callorhynchus*, *Seriolella porosa* and two soles were unfamiliar, and there also the centolla crab was to some extent supplanted by the large red oxyrhynch *Libidoclea* sp., though at some stations both were found. To the south our fauna list expanded as a result of more extensive observations in the deeper waters of the Falkland trough, and in shoal water close to the mainland. Two macrurids, a ray, *Parona signata* and *Sebastodes oculatus* were the principal additions here. Only two species new to science were recorded from the trawling stations, although the third survey was more extensive than the first two combined, and carried out under better conditions with all the added advantage of previous experience. By contrast, ten new species were found during the first two surveys. This is good evidence that the gear and methods used were adequate to provide a general picture of that portion of the fish fauna that can be sampled by trawling. The two new species discovered during the third trawling survey were *Raja multispinis* and *Notothenia macrocephala* (Norman, 1937, pp. 20, 68).

A most important addition to ideas gained from previous surveys was the discovery of rough ground at the edge of the shelf in several places, whereas Mr John had been fortunate enough to find fine, clean sand there. This rough ground produced striking examples of specialized distribution of fishes found elsewhere in shallow rocky waters but not on the shelf between.

The weight records constituted a big advance, and permit of a much better general idea of fishery prospects, the relative importance of potentially useful species, and probable breeding seasons. The observations made by Gunther and Rayner with spring balances seem amazingly accurate, from the consistency of ponderal indices (K) calculated from them. Hickling (1930*b*, pp. 7–8) has also shown that very good results can be obtained with weighings made on small ships in rough seas. With less detailed studies in view, Gunther and Rayner were weighing several fish at a time, in length groups; not individual fishes and organs as weighed by Hickling. Since the individual lengths were almost always accurately known, it is possible that for the calculation of broad mean values, such weighings are better than individual ones.

A second innovation during the third survey, that of repeat or control hauls, gave valuable evidence on the shoaling of fishes. They also showed that the nature of the bottom changes so gradually on the shelf that little would be gained (from the viewpoint of such studies as these) by a closer spacing of the stations.

During this survey Gunther recorded his opinion that 'the extreme scarcity of fish in the immediate vicinity of the Falkland Islands is unquestionably due to seals. Seals were frequently met far from the coast and seem likely to affect the fishing over a much wider area. This raises the question whether fish or sea-lions are the greater asset. While trawling on rough ground near the Falkland Islands would be difficult, so that here the sea-lion would be the more remunerative, it is possible that if their numbers were reduced fish farther afield might be turned to still greater account.' It is now known that sea-lions feed largely upon cephalopods (Hamilton, 1934), but there is little doubt that they eat considerable quantities of fish also. The cephalopods are themselves among the most important fish foods, and the way in which sea-lions frequented areas in the open sea where fish were shoaling was remarked by all who took part in the trawling surveys. The Falkland Islands are also the breeding grounds of vast numbers of oceanic sea birds, many of which eat fish whenever they can get them. These, too, probably play their part in keeping down the local fish population.

Gunther's notes also include some pertinent statements about the invertebrate fauna of the region: '*Lithodes* and squids are of direct economic importance to the South American market; macroplanktonic forms like *Parathemisto* and *Munida* spp. are among the important constituents of fish-food; the rich benthos appears to reflect the character of the sea floor, and is thus bound up with the distribution of fish. Very full notes upon the quantitative distribution of invertebrates were therefore made, but it will be impossible to make full use of them until systematists have revised the taxonomy of the several groups.' 'The plankton of the area appeared to be poorer than that of corresponding latitudes off the west coast of South America, and on the sub-Antarctic whaling grounds.' Unfortunately, one has to add that, owing to the war, most of the collections, both of plankton and of benthos, still remain to be worked up. The magnitude of this task may best be judged from a quotation from the summary of Gunther's unpublished report on the work of the third survey:

'...the OTC was shot at 80 out of 131 Sts. and repeat hauls made at 24 Sts. BTS was shot at 11 Sts., BNR at 46, oblique plankton nets at 50, and N 50 V at all Sts. Roughly 150,000 square miles between the Patagonian Coast and the Falkland Islands, and from 44° to 54° S were examined. The trawling stations were arranged in 11 lines and at a rough average were 50 mi. apart.' This report of Gunther's includes memoranda upon visits to the fish markets of Montevideo and Buenos Aires, and upon the history of the trawling industry off the River Plate, based upon the account of Devincenzi (1926). Both have been of great help to me in writing this work.

Throughout the period of these investigations and for some years afterwards, our collections were supplemented by specimens of littoral fishes obtained at the Falkland Islands by the government naturalists Mr A. G. Bennett and Dr J. E. Hamilton. Both these officers worked in close collaboration with the Discovery Investigations; indeed, Dr Hamilton was seconded for service with us for many years, his chief work being on the bionomics of the sea-lion, which happily gave opportunity for many incidental observations on shore fishes. The value of their work, especially Mr Bennett's, can best be appreciated from the frequent references to it in the main part of this paper and in Norman's (1937) systematic report on the coast fishes. Norman's work gives us the taxonomic foundation without which this could not have been written. In addition to the Discovery material he was aided by various small collections made on the mainland coast by workers to whom he has already made acknowledgement. Norman also had access to all the material from the region already preserved in the national collection.

TOPOGRAPHY OF THE SHELF

The locality and extent of the region surveyed have already been described. The names of the features most useful for general descriptive purposes are shown in the general chart of the area (Fig. 2). This chart also shows the arbitrary division into northern, southern and intermediate regions best suited to the handling of the data available. Most of the names are those of salient features of the coast and

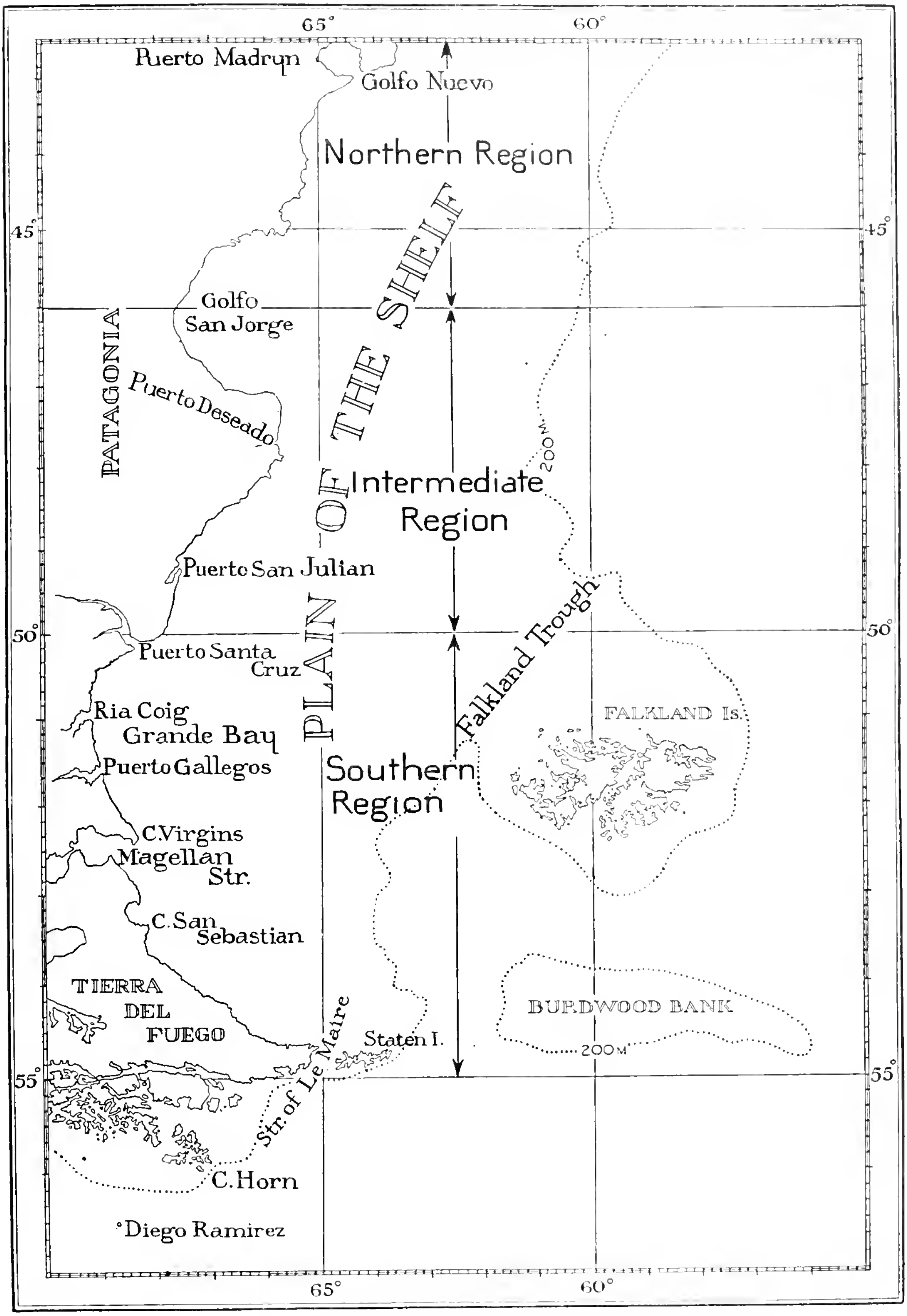

Fig. 2. General chart of the area surveyed.

require no comment. I have preferred the name 'Falkland trough' for the broad tongue of relatively deep water running north between West Falkland and the mainland, to the 'Falkland channel' of some earlier writers. In describing faunal distribution in this part of the world it is particularly important to avoid such misunderstandings as could arise by indiscriminate comparison of this natural feature with the numerous and straiter 'Magellan Channels' to the westward. The broad term 'plain of the shelf' has been used to describe the central portion of the area where the gradient of the sea floor is exceptionally slight.

The topography of the shelf has been admirably described by L. Harrison Matthews (1934, pp. 177-9) in his valuable account of the bottom deposits sampled by the conical dredge during the trawling surveys. The sections shown by him (loc. cit., Fig. 1) give ample illustration of the features that exert most influence in a study of the distribution of the fish. These are:

(1) The extremely slight gradient from 80 m. right out to the shelf edge at the 200 m. contour (the distance exceeds 200 miles in places). This is most marked in the north; farther south the sea floor slopes a little more steeply, but it is generally true to say that most of the shelf lies below water of more uniform depth than is to be found over comparable areas elsewhere. The great importance of this fact in studying fish distribution lies in the difficulties that result in interpreting depth relations, especially of migratory species. Elsewhere hake movements lead to clear correlation between size of fish and depth of water at appropriate seasons. Here the depth gradient is so slight that evidence of similar movements can only be detected when distance offshore is substituted for depth. The difficulty was augmented by areas of very slightly shallower water offshore, notably off the Golfo San Jorge and south-east of Puerto Deseado. These very slight elevations can hardly be termed 'banks'.

(2) The slope from the shelf edge to oceanic depths is very steep. In the north it is almost precipitous, so that trawling in water below 200 m. was limited to within a very few miles of the shelf edge. Farther south trawling between 200 and 450 m. was possible over a wider area, but was difficult owing to rough ground.

(3) The Falkland trough and the area of deeper water separating the Falkland Islands from the Burdwood Bank are also well illustrated by Matthews's sections.

It is possible (for our present purpose) to make a slight improvement on Matthews's general chart of the bottom topography (1934, pl. iii), by including several more recent soundings and plotting the 80 m. contour. This is shown in Fig. 3, which should be compared with Fig. 2 and with the separate distribution charts when depth relations are under consideration.

The main body of Matthews's work dealing with the grading and distribution of the deposits themselves is very instructive. The distribution of the coarser grades (mostly in the south of the area and along the landward and seaward margins of the shelf) has obvious practical significance: coarse grades, especially large fragments (loc. cit., pl. iv), usually coincide with foul ground for the trawler. Matthews's main conclusion was that deposits became finer as one proceeded northwards (fine sand and silt clearly predominate to the north), and that this is due to elutriation by the prevailing northward flowing Falkland current, which may be said to act as a natural levigator. This is one reason for the better trawling conditions found to the northward.

To extract the full benefit from Matthews's work one would need to study first the relations between the distribution of the deposits and the sessile benthic fauna which is more directly affected by the nature of the bottom than are most of the fishes. Unfortunately, as already stated, this colossal undertaking can only be begun when taxonomic revision of the main invertebrate groups is achieved. However, one very striking correlation between fish distribution and bottom deposits can already be demonstrated. The abundant occurrence of the flatfish *Thysanopsetta naresi* was almost entirely restricted to a central area of brown sand delineated by Matthews (loc. cit., pl. xii, area 'C').

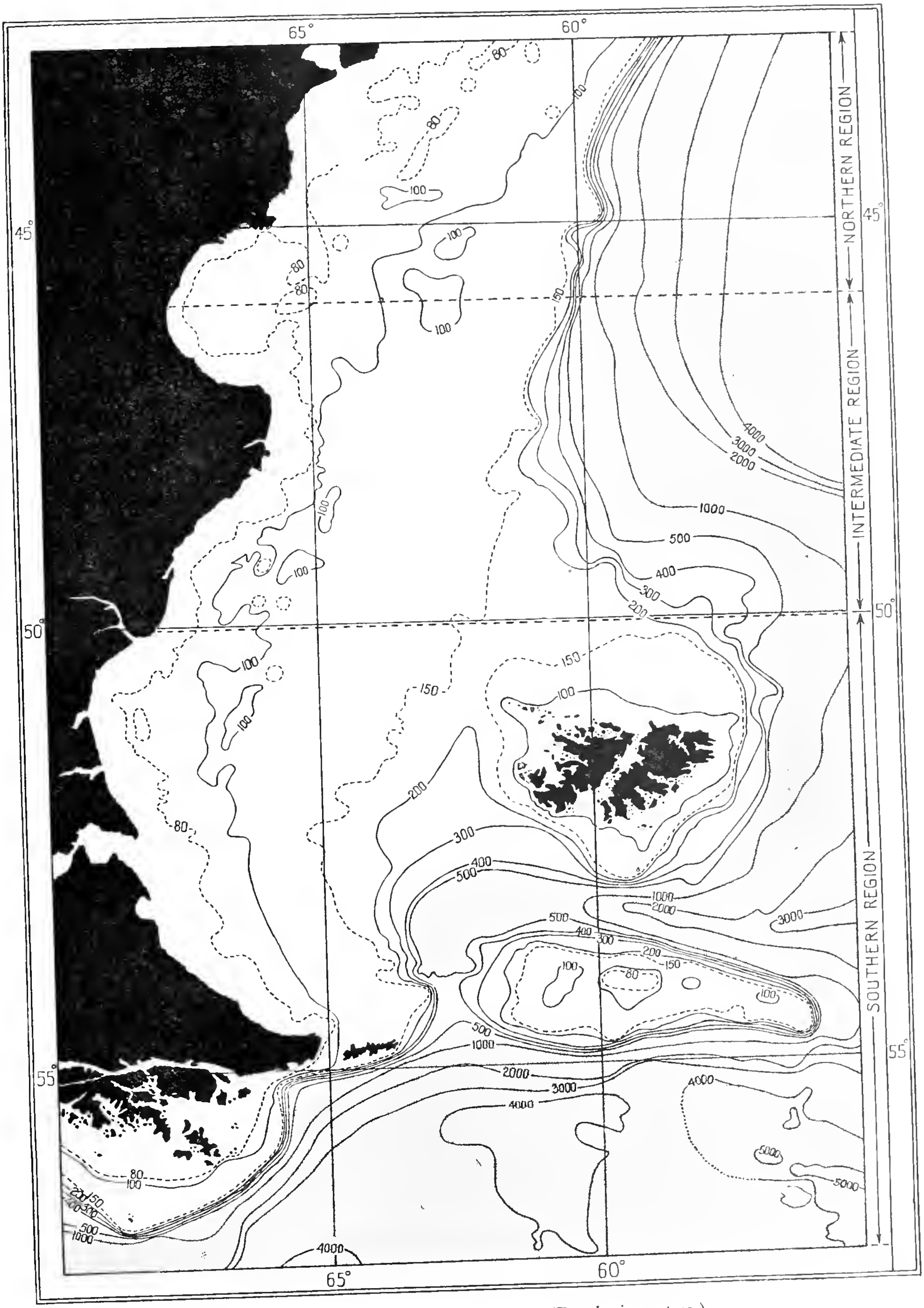

Fig. 3. Topography of the sea floor. (Depths in metres.)

Thysanopsetta is one of the important forage species for larger fish, so that the restriction to a particular type of bottom deposit, later described in detail, affords a good illustration of the potential value of Matthews's work.

HYDROLOGY

The water movements over the area covered by the trawling surveys are comparatively simple. Over the whole of the plain of the shelf and eastwards beyond the shelf edge, relatively cold sub-Antarctic water flows northwards in what is known as the Falkland current. To the east and north of the area the warmer subtropical water of the Brazil current flows southwards, and in the region of the convergence between these two (corresponding to the subtropical convergence in the open ocean still farther to the east) hydrological conditions are more complicated. Here streams of sub-Antarctic and subtropical surface waters may alternate, giving rise to large differences in salinity and temperature within a few miles. Klaehn (1911) was able to trace the southward movement of the Brazil current as far as 49° S to the north-east of the Falkland Islands, but Deacon (1937, pp. 58–9) has shown that south of about 43½° S, the subtropical water is becoming more and more mixed with sub-Antarctic water. The influence of the Brazil current is strongest in summer, when relatively unmixed subtropical water may extend some 4° farther south than in winter. The complicated conditions around the southern extremity of the Brazil current rarely impinge on the trawling area, but this is the probable route by which fishes that normally live in warmer seas occasionally reach the north-east coasts of the Falkland Islands. The main facts concerning the southward limits of the Brazil current have been ably summarized by Deacon (1937) and an attempt has been made to depict them in Fig. 4, which should be regarded as a pictorial representation of the current system, and not an exact hydrological study.

The Falkland current, which bathes most of the shelf, is composed of sub-Antarctic surface water. Deacon (loc. cit., p. 51) has described how the main west-wind drift of the south Pacific is compressed while passing through Drake passage. This augments its speed, and the sub-Antarctic portion of it is swollen by a relatively small amount of warmer, poorly saline coastal water flowing southwards down the south-west coast of Chile. The resultant of these forces is the so-called Cape Horn current, which is really a local intensification of the west wind drift. It sometimes reaches a speed of as much as 40 miles per day.

To the east of Staten Island the Cape Horn current divides in the form of the greek letter γ, the lesser branch swinging north round the Falkland Islands, but mainly between them and the mainland, to form the Falkland current; and the main branch proceeding north-east and then east until it merges into the main easterly (i.e. 'west wind') drift of the open ocean south of the Atlantic.

The Falkland current itself flows most rapidly on its right flank, well offshore and beyond the shelf edge, outside our immediate area. It is here that the coldest water is found, but the lower temperatures are not caused solely by the greater speed of flow than that obtaining over the shelf. Both Krümmel (1911) and Klaehn (1911) postulate upwelling as an additional source of the cold water. Where the Brazil and Falkland currents are flowing in opposite directions alongside each other it is natural to suppose, as did Klaehn, that the dynamic disturbances so set up favour the creation of whirls with consequent upwelling. Deacon (1937) considers that Klaehn's demonstration (1911, pl. 35, fig. 4) of isolated patches of relatively cold water towards the northern end of the Falkland current is proof of upwelling, but our own data did not then provide any fresh evidence of its mechanism.[1]

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[1] In fairness to all concerned it must be realized that the examination of much data collected by the Discovery Committee's ships in this region has necessarily been deferred on account of the war.

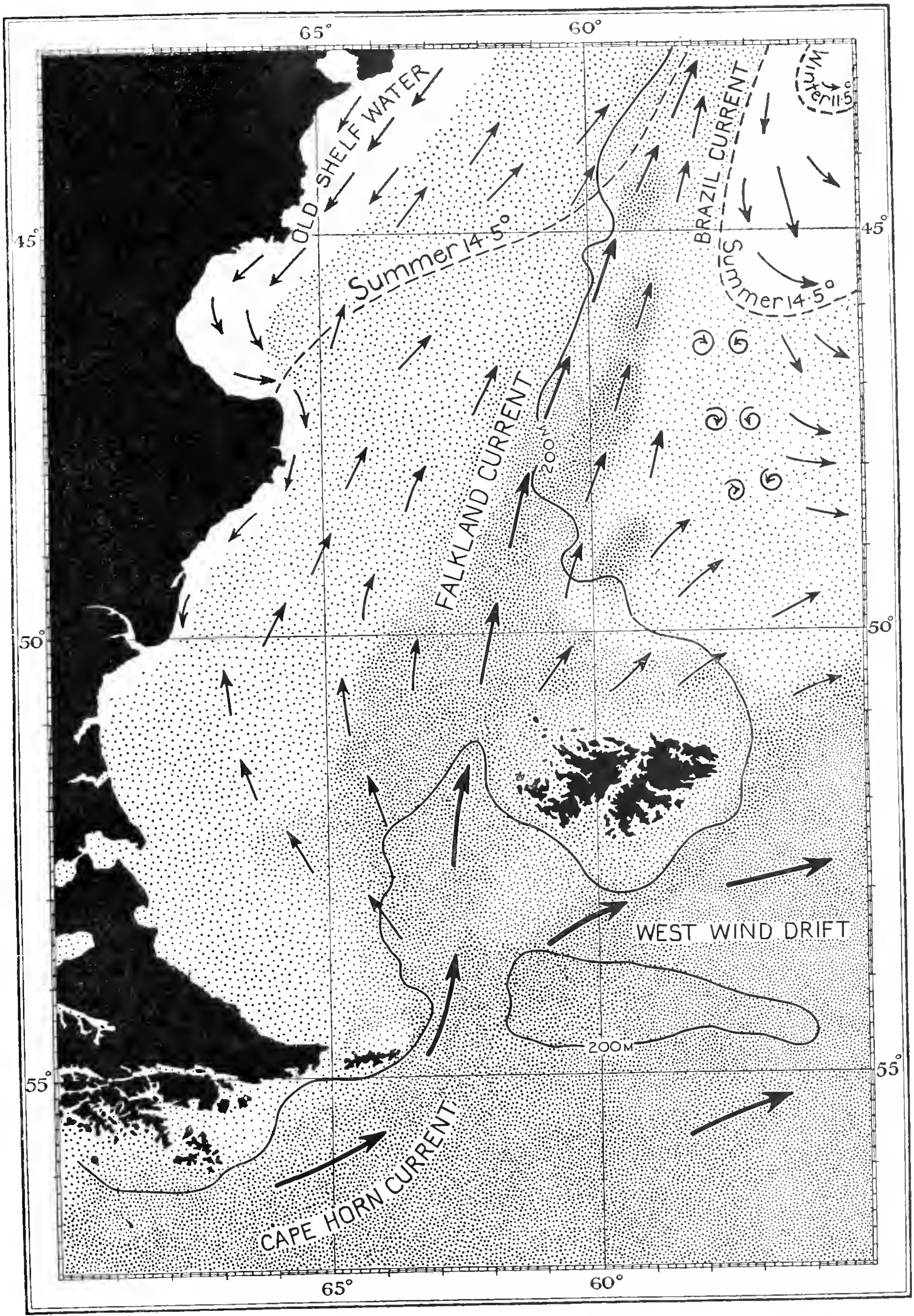

Fig. 4. Current system of the area surveyed. Black stipple indicates cold currents, and red indicates *relatively* warm currents.

The steep slope of the shelf edge is almost certainly one of the factors involved. These complications in the coldest part of the Falkland current occur mainly to the eastward of the trawling area, and therefore need not concern us further here.

Along the mainland coast the speed of the Falkland current is greatly reduced and close inshore southerly movements of surface water may predominate. Consequently the water close to the mainland is warmer than that over the plain of the shelf. A definite counter-current close to the beach is set up in the summertime, which may flow (more intermittently) at other seasons also. These inshore conditions are clearly indicated by the direction of the isotherms in Klaehn's charts (1911, pl. 35). The warmer inshore water does not result from any southward translocation of subtropical water, like the Brazil current offshore. The latter begins to swing away from the land well to the north of our area, usually in about 30° S. The warmer inshore water is formed by 'warming-up' of sub-Antarctic water, owing to the slower rate of advance on the left flank of the Falkland current. It may be described as '*old* shelf-water'.

In the area of the trawling surveys there are only these two main hydrological features to be visualized, the northward flow of the Falkland current over the plain of the shelf, colder and faster[1] offshore along the shelf edge; and the old warmer water close inshore with a more or less definite southerly trend.

It is helpful in considering the distribution of fishes to gain some idea of the annual cycle of temperature of the water. This enables some direct comparison to be made with conditions on better-known fishing grounds elsewhere. Here we are handicapped by the fact that our three surveys were made at different seasons in different years. Klaehn's very thorough averaging of results from many years' observations, at a time when the region was much more important for traffic,[2] provides the general picture we need, though it deals with surface waters only. From a careful check of Klaehn's charts against our own results it appears that the three years in which our own surveys took place must have conformed closely to the 'average' conditions depicted by him. Comparing observed temperatures obtained with the best modern apparatus on our surveys with Klaehn's monthly means, we find a resultant mean error of −0·26° C. in autumn, −0·40° C. in winter and −0·07° C. in summer. The range of error introduced by 'assuming' Klaehn's mean values instead of our own would be −1·01 to +0·49° C., −1·35 to +0·81° C., and −3·21 to +1·95° C. respectively. Some error must be introduced by the time interval between our individual observations and the middle of the month, the rest may be confidently attributed to diurnal variations, as indicated by the discrepancy being greatest in summer. Klaehn worked on ten years' records from sailing ships (doubtless mainly nitrate clippers) and four years' records of the German Admiralty. We know that two years (1896–7 and 1906–7) out of the total studied by him were exceptionally cold, with icebergs drifting far north in the Falkland current (Krümmel, 1911, p. 606, fig. 172). Such conditions are rare, and this fact alone is probably sufficient to account for the slight tendency of Klaehn's values to be lower than ours, especially in winter. More important still, a comparison between the observed differences in surface temperature between successive pairs of our own observations, and the differences that would be expected from Klaehn's results revealed a close correlation ($r = +0{\cdot}85$, with P much less than 0·01). It seems clear, therefore, that Klaehn's results give a very adequate picture of the 'average' conditions, which will give a more satisfactory idea of the annual cycle of surface temperature than any scheme of plotting our less numerous and more scattered observations with interpolations for the gaps.

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[1] Some 13 sea miles per day according to Klaehn (1911).

[2] Like many other parts of the southern ocean, this region was far better known during 'the last days of sail' than subsequently.

Graphs for the annual cycle have been plotted from Klaehn's charts in Fig. 5. The three positions have been chosen arbitrarily on account of their approximation to the centres of the most numerous of our observations on the fishes of the shelf, in each of the three main latitudinal regions into which our stations may be grouped. The curves show that the temperatures in our 'Northern region' are very slightly colder than those found (say) on the hake grounds south of Ireland. The range is similar, but the winter temperatures nearly 1° C. lower. The temperature cycles plotted for our 'intermediate' and 'southern' regions show a decrease with increasing latitude, as is to be expected; while the three curves together show the diminution in annual range as one proceeds southwards. This is also well illustrated by Klaehn (1911, pl. 34, 'Jahresamplitude der Wassertemperatur').

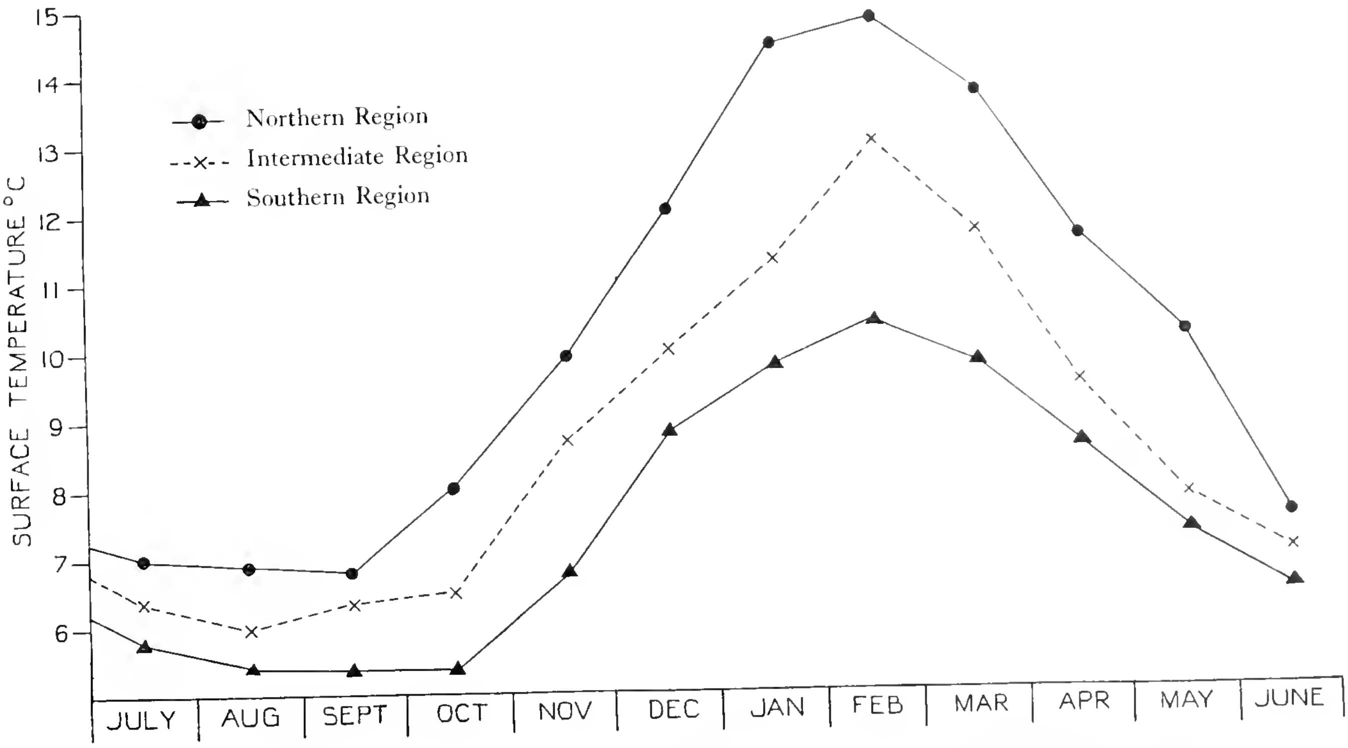

Fig. 5. Representative annual surface-temperature cycles for the plain of the shelf, after Klaehn (1911).

For consideration of the bottom temperatures, which are more significant in relation to our trawled samples of fishes, we have only our own scattered observations to go upon. The actual figures are given in Appendix I. It is obviously impossible to show typical seasonal curves, like those derived from Klaehn's monthly charts of surface temperatures, owing to the small proportion of these observations that fall within any one depth range over a reasonably restricted area. A single, partly hypothetical, curve for the intermediate region is shown in Fig. 6. With this as a rough guide it is possible to perceive some important features by simple inspection of the figures quoted in the Appendix. The seasonal cycle appears to be centred later in the year in the bottom water, with maximum temperatures in March. In autumn and the first half of the winter there is much less difference in temperature between surface and bottom water than at other seasons; it is rarely more than 2° C., whereas in summer it usually amounts to some 4° C. This is due to intense mixing over the shelf in winter, already described by Deacon (1937, p. 51). In spring and early summer, even in the northern region, some temperatures below 5° C. were recorded (lower than the winter values), but most of these were in fairly deep water well offshore.

These bottom temperatures are particularly important in their relation to the most promising fish of the region, the Patagonian hake. It is quite clear, from the general run of the figures, that these are plentiful at some seasons in waters where the bottom temperatures are around 6° C. Their lower limit seems to be some 3° below the figure 8·7° C. which Hickling (1927, p. 67; 1928, pp. 81–2, 88) found to be the normal cold limit of penetration of European hake. The 'stumpies' of the Norwegian deep are commonly found at lower temperatures, it is true; but Hickling's later work provides ample evidence that they are a local race, unrepresentative of the main stock, quite apart from the temperature of the waters in which they are found (Hickling, 1930*b*, pp. 50–1).

The bottom temperatures north and south of that part of the shelf represented by our 'partly hypothetical cycle' seem to vary with the seasons in similar fashion. To the north they probably 'average' 1° C. warmer, and to the south perhaps 1° C. colder (certainly so in summer). The main feature is the lag of at least a month after the surface maximum, and the relatively high autumn and winter values due to mixing. For this reason the seasonal graph does not fall anything like so steeply as does that showing the surface temperatures, from the maximum to midwinter.

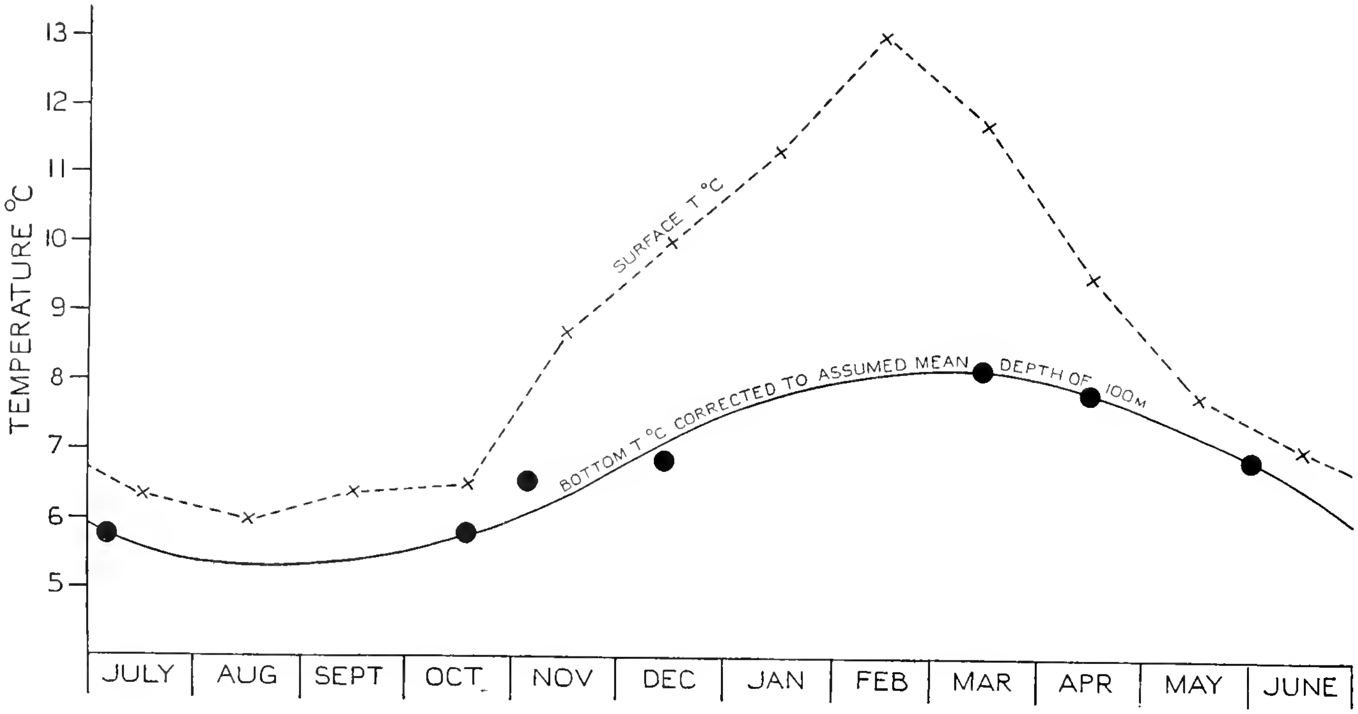

Fig. 6. Bottom temperature on the shelf; partly hypothetical annual cycle for the intermediate region, corrected to an assumed mean depth of 100 m., with surface cycle for comparison.

Observations of the nutrient salt content of the waters of the Falkland current are not yet available for this area.

PLANKTON

During the trawling surveys some phytoplankton samples were collected from the waters of the shelf with the Gran net. They have not been fully analysed because of pressure of other work. Most were obtained during the third survey. Mr Rayner made some preliminary observations on them (unpublished) and has recorded his impression that they indicate a poorer phytoplankton than that found off the west coast of South America. Some of our early phytoplankton work in the 'Discovery II' extended northwards, to the extreme south of the trawling survey area, and there we found some evidence of a secondary autumnal increase in March 1930, with *Rhizosolenia* spp. dominant (Hart, 1934, pp. 73–5, 79).

Our later work from 1933 onwards was based on results obtained by Harvey's (1934) method. I have not previously dealt with our results from the sub-Antarctic Zone, because they were relatively few and widely scattered, not lending themselves to the methods of presentation adopted in dealing with the Antarctic material, which was the main object of study (Hart, 1942). Although most of these observations are from oceanic waters, I think it profitable to discuss them briefly here, since they seem to me to give a good indication of the type of seasonal cycle (of standing crop) that may be expected on the shelf. In November 1936 several observations were made on the shelf and in the oceanic waters just beyond the shelf edge. These showed very little phytoplankton on the shelf but some rich hauls offshore.

The widely scattered observations available throughout the sub-Antarctic Zone, north of 54° S, are shown as a scatter plot in Fig. 7. No grouping of these observations by time intervals would permit calculation of means that could be plotted to show the seasonal variation effectively. Owing to the small numbers of observations and their wide dispersion, the differences between the monthly means, for example, would not be statistically significant. Wide dispersion is a common source of difficulty in all 'samples' of quantitative estimations of phytoplankton, whatever method is adopted. It seems certain that it is due to the extremely patchy distribution of these organisms in nature, though all methods have limitations that may exaggerate this feature. Plotting the logarithms of the individual observations instead of the actual numbers of units per m.^{3} overcomes another great difficulty due to wide dispersion: that of finding a scale on which all the observations can be shown. The observations shown were not all obtained in the same year and, as already stated, they were scattered throughout the sub-Antarctic Zone, but apart from the logarithmic plotting they have not been otherwise manipulated in any way. Moreover, nearly all the species involved have a completely circumpolar distribution, as in the Antarctic Zone to the southward.

The figure shows clearly that the only months in which hauls exceeding 1000 units per m.^{3} occurred were November, December and March. Further, the proportion of very small hauls, below 100 units, was less in these months than in any of the others. A seasonal cycle similar to that postulated for the northern oceanic waters of the Antarctic Zone (Hart, 1942, pp. 307–8), but centred slightly earlier in the year, is suggested.

What, then, is the explanation of the low values recorded over the shelf in November 1936? The main increase on the shelf must take place either earlier or later than that in the oceanic waters.

Gran (1929), working off the Norwegian coast, found that the increase took place first in the inshore water (Romsdalsfjord), secondly (but only a week later) at the edge of the coast bank outside (Storeggan) and lastly spread over the intervening shelf. On this analogy the main increase on the shelf would not take place until December in our southern locality. But conditions in the two areas are not comparable in several important respects. The Patagonian shelf is much wider and more uniform in depth, the latitude lower, and the current a relatively cold one flowing towards the equator. Off Norway a relatively warm current is flowing away from the equator.

We know that in the Antarctic Zone the phytoplankton cycles are centred much later in the year than in corresponding latitudes in the northern hemisphere, and in the northern part of that zone the cycle is centred *earlier* in the year in coastal waters than in oceanic ones (Hart, 1942, p. 330). We have seen that, as in the Antarctic, the time of the main increase in oceanic sub-Antarctic waters is remarkably late (5th to 6th months of the year) as compared with conditions in the northern hemisphere. I therefore think it probable that the coastal waters of this zone will also show a main increase considerably earlier than the oceanic ones, and that the post-maximal decrease had already begun in the

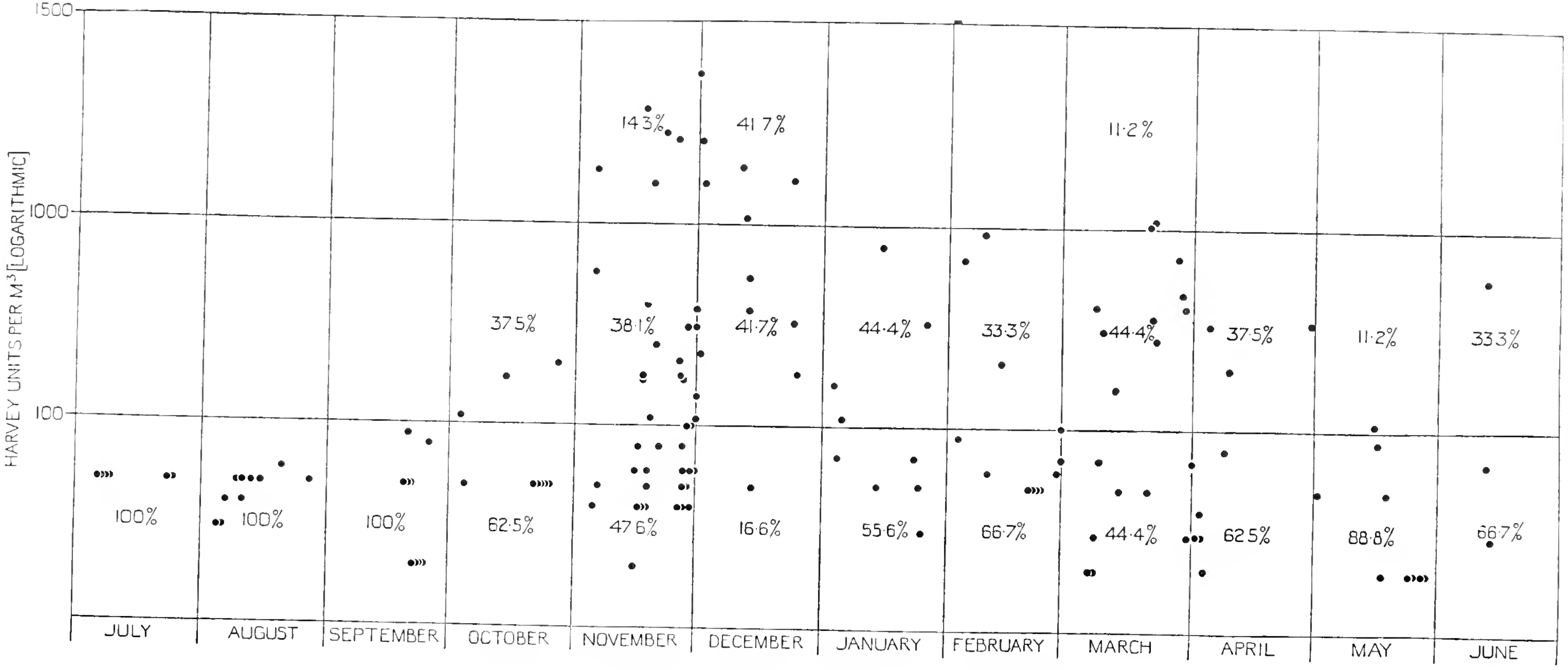

Fig. 7. Seasonal variation in size of sub-Antarctic hauls of phytoplankton.

shelf waters sampled in November 1936. The fact that the temperatures diminish as one proceeds offshore supports this view. There should be an earlier tendency towards establishment of a thermocline, favouring earlier onset of the main diatom increase, under the warmer conditions prevailing inshore.

It is thus probable that over the area of the trawling surveys the times of maximal production of phytoplankton are only slightly later than in corresponding latitudes in European waters, and not so much later as in the oceanic sub-Antarctic waters beyond the edge of the shelf.

The effect upon fishes of a slightly later timing of this basic element in the 'plankton-calendar' of the locality is likely to be a corresponding shift in their own dispositions, in so far as these are affected by the plankton, for it is generally true that zooplankton maxima follow the maximal 'standing crop' of phytoplankton. Some of the evidence on this point has recently been well summarized by Bogorov (1941).

One of the most striking features of the zooplankton of the region is the swarming of lobster-krill (the *Grimothea* post-larval pelagic stages of *Munida gregaria*), which occurs most frequently during the summer months. The adults of this anomuran also swarm at the surface occasionally. The swarms of post-larvae are often thick enough to impart a reddish appearance to the surface of the sea, observed by many of the earliest navigators of these waters (Matthews, 1932, pp. 479–81, several references). The later phases of this species are limited to coastal areas round the Falkland Islands and along the mainland coast, within our area (Rayner, 1935, fig. 18). A closely allied form, *M. subrugosa*, is even more widespread and abundant on the shelf (Rayner, 1935, p. 238, fig. 17). The later stages of this species are more strictly bottom dwellers. *Munida* spp. are of great importance in the ecology of the region, as a staple food of whales (Matthews, 1932, pp. 481–3), seals (Hamilton, 1934, p. 295), birds and fishes. *M. gregaria* is also found fulfilling a similar role in New Zealand waters (numerous references quoted by Matthews). Other allied species of Anomura are equally important in the north Pacific, off Mexico and southern California (information supplied by Capt. Fagerli and by Dr Waldo L. Schmidt of the Smithsonian Institute, quoted by Matthews, 1932, p. 472).

Rayner's detailed work on the growth of the Falkland species of *Munida* shows that they are comparatively long-lived (5 years or more of post-larval life in *M. subrugosa*) and are sexually mature from the end of the first year of post-larval life. The Antarctic krill, *Euphausia superba*, belonging to a less specialized group, and pelagic throughout its life history, lives for a much shorter time. The distinctive differences in pelagic life of the two regions may be affected by this difference in the life history of their respective key-industry animals, as well as by the more obviously important physical factors.

Euphausians are quite important constituents of the macroplankton over the shelf, but are obviously less important than in the Antarctic. None have been observed to form dense swarms discolouring the surface of the sea, as *E. superba* commonly does in the Antarctic, and as *Meganyctiphanes norvegica* (perhaps also *Thysanoëssa inermis*) more rarely do in north European waters. Two or more southern species of *Thysanoëssa* are to be found over the shelf, and of these *T. gregaria* is the most abundant. From John's (1936) work we know that of the genus *Euphausia*, *E. vallentini* is the most widespread and possibly the most numerous species around the Falkland Islands and in our 'southern region'. *E. lucens*, *E. similis*, *E. longirostris* and *E. triacantha* also occur. Judging by its general distribution throughout the sub-Antarctic Zone, *E. lucens* may be the most important species on the shelf farther north, but quantitative data are not yet available.

The ubiquitous hyperid amphipod *Parathemisto gaudichaudii* is abundant on the shelf, and fish were frequently found to have been feeding upon it. Numerous calanoid copepods occur, and local abundance of large Scyphomedusae is frequently referred to in the log books. The general facies of the zooplankton is indeed not unlike that of north European waters, but important differences may be expected to appear, especially in the times of maximum abundance of the different groups, when the material is fully worked up. As already explained, however, this must wait upon the completion of taxonomic revision of the groups. Moreover, the environmental features of an area of this size, both physical and biological, present almost unlimited scope for further investigation. In general we may say that most of the more important macroplanktonic forms have a wide, often a circumpolar distribution within the sub-Antarctic Zone. They are noticeably less restricted than the benthos in their latitudinal range also, including a higher proportion of species that may extend into the distinct water-masses both to the south and to the north of the sub-Antarctic Zone. Among microplankton forms this wide tolerance is even more marked; many of them are cosmopolitan.

METHODS OF PRESENTATION

It has not been considered advisable to attempt to publish the biometric data on fishes in full, for the raw data alone in manuscript form weigh over 1 cwt. These papers will be stored by the Discovery Committee, and it is hoped that much information may still be gleaned from them.

Full details of the station positions are appended, with some of the abstracted data on the most important fishes. The numbers of fishes recorded are shown with station numbers only, in the general distributional accounts of each species. Wherever it has been found profitable to consider length and weight measurements these are given in the form of summarized tables and diagrams with legends which it is hoped contain sufficient explanation. The data relating to different species varies so much that it is obviously impossible to adopt uniform treatment throughout.

Such simple statistics as have been ventured upon relate mainly to length-frequency distributions and mean lengths. Where mean lengths have been used to compare or contrast catches from different stations or groups of stations I have included sufficient information as to dispersion to enable the significance of the differences to be determined. Simpson and Rowe's book (1939) has been a great help in dealing with the numerical data.

The systematic arrangement and taxonomy of the fishes follow Norman's report (1937) throughout. In discussing bionomics of the fishes I have stressed differences and resemblances between Patagonian species and those most nearly allied to them that have already been studied on better-known fishing grounds elsewhere. I believe that it is easier for readers without experience of this particular area to visualize the conditions if they are presented in this way. Since hake are the most important species on the shelf, I have tested out the theories developed by Hickling during his prolonged work on the European species, in so far as our scantier data on the Patagonian species permit. With the possible exceptions of cod, haddock, herring and plaice, Hickling's work on hake probably constitutes the most complete picture we have of the life history of any marine fish. Consequently all members of the Discovery staff who have been concerned in this work have studied Hickling's work intensively.

Two conventions have been used to facilitate general descriptions of fish distribution, and to ensure that seasonal comparisons should be kept roughly comparable:

First, the whole area has been arbitrarily subdivided into 'northern', 'intermediate' and 'southern' regions, according to latitude. The interval chosen was 4° of latitude, so that the northern region includes all trawling survey stations north of 46° S, the intermediate region all those between 46 and 50° S, and the southern region all those south of 50° S. This subdivision has already been indicated in Fig. 2. It is an arbitrary division introduced solely for the purpose of reducing the data to manageable proportions, but it approaches a natural division inasmuch as the physical conditions that change with latitude affect the flora and fauna. Provided that large-scale migrations in a north and south direction are not involved, observations at different seasons within any one of these regions are obviously more fairly comparable than those over the whole area. In the specific distribution lists, the regions to which individual stations belong are indicated by printing the numbers of **northern** stations in **heavy type**, intermediate stations in ordinary type, and *southern* stations in *italics*.

Secondly, the reversal of the seasons in the southern hemisphere is indicated by beginning all time scales on 1 July, comparable to 1 January in the northern hemisphere. It should also be remembered that when the looser seasonal expressions 'spring', 'summer', etc., are used, a similar reversal is implied.

Owing to the slight gradient on the shelf, distance from the mainland coast is more significant in relation to seasonal changes in distribution than changes in depth of water inhabited by migratory species. This figure has been calculated (in sea miles) for all the stations and is tabulated in Appendix I. Conditions round the Falkland Islands themselves are peculiar, and they do not appear to be regarded as a coast at all by the main migratory species, which are almost absent from their immediate vicinity. I have therefore calculated the distance from the nearest point of the Falkland Islands also, for those stations that fall within 100 sea miles of them. Beyond that distance migratory fishes seem to proceed towards the mainland (in due season) as though the Falkland Islands did not exist, even though the mainland may be twice as far distant. The exact distances from the Falkland Islands of all other stations has not, therefore, been calculated; they are tabulated merely as 'more than 100 miles'.

Abbreviated descriptions of gear are the same as those used throughout the station lists in *Discovery Reports*. The meanings of those used in this work have already been given in the section on field methods.

GENERAL ACCOUNT OF THE FISH FAUNA

A list of all the species of fishes recorded on the Patagonian Continental Shelf and immediately adjacent coasts is given in Table 1. This also shows which species were obtained during the surveys in 'Trawl+accessory nets', in 'Other gear' and by shore parties. Most of the specimens recorded in the last category were obtained by Mr A. G. Bennett and Dr J. E. Hamilton. I have not included some recent records of Pozzi and Bordale (1935) which are mentioned by Norman (1937, pp. 145–6). Some of these require confirmation. The list follows that of Norman (loc. cit., pp. 143–5) but omits species recorded only from the west coast (columns A and B of Norman's list). The historical aspect of the growth of our knowledge of the fish fauna is admirably dealt with by Norman (1937, pp. 137–46), and from his account the debt we owe to earlier expeditions—British, French, Swedish and American—can be assessed.

From Table 1 it can be seen that ninety-five species are recorded from the region, and specimens of seventy-eight of these were obtained by ships or shore parties in the course of the Discovery investigations. Also an undoubted basking-shark was observed. The records of two of the species that we did not capture seem somewhat doubtful: *Bunocottus apus* Kner is based on a single specimen said to have come from the Burdwood Bank, no other Cottidae are known from the region, and Kner's description does not agree with his figure (cf. Norman, 1937, p. 145). *Alphestes afer* (Bloch), a small serranid common in the West Indies, has a normal range extending from Cuba to Brazil (Jordan and Eigenmann, 1890, p. 350). It is clearly a tropical species, so that its occurrence south of 42° S would be most extraordinary, and I am unable to trace the authority upon which Norman placed it in the Patagonian list. Among the other species not taken on the surveys, *Notothenia trigramma* Regan and *Crossostomus fasciatus* (Lönnberg) are known only from their unique holotypes, and it is possible that

Table 1. *Fish fauna of the Patagonian Continental Shelf*

Family	Species	Taken in 'Trawl + accessory nets'	Taken in 'Other gear'	Taken by shore parties	Common names adopted in this report
Petromyzonidae	*Geotria australis* Gray	—	—	×	—
	Myxine australis Jenyns	×	×	×	Hagfish
	**M. affinis* Günther†	—	—	—	—
Lamnidae	**Cetorhinus maximus* (Gunner)‡	—	—	J.E.H. obs	Basking shark
Scyliorhinidae	**Scyliorhinus* (*Halaelurus*) *bivius* (Smith)†	—	—	—	Dogfish
Carcharinidae	**Mustelus canis* (Mitchill)	—	—	—	
	**Centroscyllium granulatum* (Günther)	—	—	—	
Squalidae	*Squalus lebruni* (Vaillant)	×	—	—	
Torpedinidae	*Discopyge tschudii* Heckel	×	—	—	Rays
Rajidae	*Raja flavirostris* Philippi	×	—	—	
	R. doello-juradoi Pozzi	×	—	—	
	R. macloviana Norman	×	—	—	
	R. magellanica Steindachner	×	×	—	
	R. multispinis Norman	×	—	—	
	R. scaphiops Norman	×	—	—	
	R. brachyurops Fowler	×	×	—	
	R. griseocauda Norman	×	—	—	
	Psammobatis extenta (Garman)	×	—	—	
	P. scobina (Philippi)	×	×	—	
Chimaeridae	*Callorhynchus callorhynchus* (Linnaeus)	×	—	—	—
Clupeidae	*Clupea fuegensis* Jenyns	×	×	×	'Herring'
	C. arcuata Jenyns	×	—	—	'Sprat'
Galaxiidae	*Galaxias attenuatus* (Jenyns)	—	—	×	—
	**G. maculatus* (Jenyns)	—	—	—	—
	**G. smithii* Regan	—	—	—	—
Aplochitonidae	*Aplochiton zebra* Jenyns	—	—	×	—
	**A. taeniatus* Jenyns	—	—	—	—
Syngnathidae	*Leptonotus blainvilleanus* (Eydoux and Gervais)	×	—	—	Pipefish
	**Entelurus aequoreus* (Linnaeus)	—	—	—	—
Macruridae	*Coryphaenoides holotrachys* (Günther)	×	—	—	—
	Coelorhynchus fasciatus (Günther)	×	—	—	—
Merlucciidae	*Merluccius hubbsi* Marini	×	×	—	Hake
	Macruronus magellanicus Lönnberg	×	—	—	'Long-tailed hake'
Gadidae	*Micromezistius australis* Norman	×	—	—	—
	Salilota australis (Günther)	×	—	—	—
	Physiculus marginatus (Günther)	×	—	—	—
Muraenolepidae	*Muraenolepis microps* Lönnberg	×	—	—	—
	M. orangiensis Vaillant	×	—	—	—
Lamprididae	*Lampris regius* (Bonnaterre)	—	—	×	—
Serranidae	**Alphestes afer* (Bloch)	—	—	—	—
Carangidae	*Parona signata* (Jenyns)	×	—	—	—
Cheilodactylidae	*Cheilodactylus bergi* Norman	—	×	—	—
Bovichthyidae	*Cottoperca gobio* (Günther)	×	×	—	—
	Bovichtus argentinus MacDonagh§	—	—	×	—
Nototheniidae	*Notothenia macrophthalma* Norman	×	—	—	—
	**N. trigramma* Regan	—	—	—	—
	N. canina Smitt	×	×	—	—
	N. jordani Thompson	×	×	—	—
	N. tessellata Richardson	×	×	×	—
	N. brevicauda Lönnberg	—	×	×	—
	N. guntheri Normann	×	×	—	—
	N. ramsayi Regan	×	×	—	—
	N. wiltoni Regan	—	×	×	—
	N. squamiceps Peters	—	×	—	—
	N. sima Richardson	—	×	×	—
	N. cornucola Richardson	—	×	×	—
	N. elegans Günther	×	×	—	—

Table 1 (*continued*)

Family	Species	Taken in 'Trawl + accessory nets'	Taken in 'Other gear'	Taken by shore parties	Common names adopted in this report
Nototheniidae	*Notothenia macrocephala* Günther	—	×	×	—
	**N. microlepidota* Hutton	—	—	—	—
	Dissostichus eleginoides Smitt	×	—	—	—
	Eleginops maclovinus (Cuvier and Valenciennes)	—	×	×	'Mullet'
Harpagiferidae	*Harpagifer bispinis* (Schneider)	×	×	×	—
Chaenichthyidae	*Champsocephalus esox* (Günther)	×	×	×	—
Gempylidae	*Thyrsites atun* (Euphrasen)	×	×	×	—
Scombridae	*Gasterochisma melampus* Richardson	—	—	×	—
Zoarcidae	*Iluocetes fimbriatus* Jenyns	×	×	—	—
	I. elongatus (Smitt)‖	×	×	—	—
	Austrolycus depressiceps Regan	—	—	×	—
	**A. laticinctus* (Berg)†	—	—	—	—
	Phucocoetes latitans Jenyns	×	×	×	—
	**Crossostomus fasciatus* (Lönnberg)	—	—	—	—
	Pogonolycus elegans Norman	×	×	—	—
	Platea insignis Steindachner	—	×	—	—
	**Maynea patagonica* Cunningham	—	—	—	—
	M. brevis Norman‖	×	—	—	—
	Melanostigma microphthalmus Norman	×	—	—	—
Ophidiidae	*Genypterus blacodes* (Schneider)	×	×	—	—
Brotulidae	*Cataetyx messieri* (Günther)	×	—	—	—
Centrolophidae	*Seriolella porosa* Guichenot	×	—	—	—
	Palinurichthys caeruleus (Guichenot)	×	—	—	—
	P. griseolineatus Norman	×	—	—	—
Stromateidae	*Stromateus maculatus* (Cuvier and Valenciennes)	×	—	—	'Spotted pomfret'
Atherinidae	*Austromenidia smitti* (Lahille)	—	×	×	'Smelt'
	A. nigricans (Richardson)	—	—	×	
Scorpaenidae	*Sebastodes oculatus* Cuvier and Valenciennes	×	—	—	—
Congiopodidae	*Congiopodus peruvianus* (Cuvier and Valenciennes)	×	—	—	—
Cottidae [?!]	**Bunocottus apus* Kner [?!]	—	—	—	—
Psychrolutidae	*Neophrynichthys marmoratus* Gill	×	×	—	—
Agonidae	*Agonopsis chiloensis* (Jenyns)	×	×	—	—
Liparidae	*Careproctus falklandicus* (Lönnberg)	×	—	—	—
	**Liparis antarctica* Putnam	—	—	—	—
Bothiidae	*Thysanopsetta naresi* Günther	×	×	—	'Scald fish'
	Paralichthys isosceles Jordan	×	×	—	—
	Xystreurys rasile (Jordan)	×	—	—	—
	Mancopsetta maculata (Günther)	×	—	—	—
	Achiropsetta tricholepis Norman	×	—	×	—

* Species not taken during the surveys.

† Species not taken in this area, but specimens obtained by the expedition elsewhere. ‡ Observed, but not taken.

§ Taken by Mr MacDonagh at Puerto Madryn. ‖ Species taken only in 'Accessory nets' when trawled.

the latter may prove to be a young example of *Austrolycus depressiceps* Regan (Norman, 1937, p. 106). Specimens of three species, recorded from the shelf but not taken there by us, were obtained on other occasions among the channels to the westward.

Of our seventy-nine 'shelf' species, sixty-one were obtained in the 'Trawl + accessory nets', thirty-five in 'Other gear' (including ten that were not trawled), and twenty-three by shore parties (including seven not taken by other means), the total being made up by the basking shark seen by Dr Hamilton. Thus we see that of the ninety odd species recorded from the region, two-thirds were obtained by trawling. The remainder are mainly littoral fishes; for example, eight of the notothenias and two zoarcids have never been taken in water deeper than 46 m. (25 fm.). The difficulties of obtaining littoral fishes in this area are great: the tidal range is small and the surf often heavy, while the great

Table 2. *Fish fauna of the Patagonian Continental Shelf (trawled fish only). Total numbers taken and frequency of occurrence*

Numerical class	Species	Total nos. of fish taken	Frequency of occurrence in 178 hauls	Frequency of occurrence as percentage
> 1000	*Notothenia ramsayi*	9599	130	73·0
	Merluccius hubbsi	5748	109	61·2
	Macruronus magellanicus	5336	63	35·4
	Thysanopsetta naresi	1916	33	18·5
	Stromateus maculatus	1044	51	28·7
100–999	*Clupea fuegensis*	694	28	15·7
	Micromezistius australis	557	21	11·8
	Salilota australis	485	65	36·5
	Cottoperca gobio	414	50	28·1
	Raja brachyurops	274	48	27·0
	Notothenia guntheri	267	11	6·2
	Psammobatis scobina	153	45	25·3
	Coelorhynchus fasciatus	140	12	6·7
	Champsocephalus esox	124	15	8·4
	Notothenia tessellata	102	9	5·1
50–99	*Coryphaenoides holotrachys*	95	8	4·5
	Genypterus blacodes	74	33	18·5
	Raja doello-juradoi	68	12	6·7
	R. magellanica	54	21	11·8
	Congiopodus peruvianus	50	16	9·0
25–49	*Agonopsis chiloensis*	47	15	8·4
	Thyrsites atun	45	6	3·4
	Raja flavirostris	41	24	13·5
	Clupea arcuata	39	1	0·6
	Iluocetes fimbriatus	38	22	12·4
	Parona signata	35	2	1·1
	Notothenia canina	30	5	2·8
	Callorhynchus callorhynchus	28	6	3·4
	Notothenia jordani	25	3	1·7
	Neophrynichthys marmoratus	25	7	3·9
1–24	*Myxine australis*	24	7	3·9
	Raja macloviana	23	12	6·7
	Physiculus marginatus	22	4	2·2
	Dissostichus eleginoides	9	5	2·8
	Squalus lebruni	8	6	3·4
	Seriolella porosa	8	1	0·6
	Raja griseocauda	8	6	3·4
	Paralichthys isosceles	8	5	2·8
	Raja scaphiops	7	5	2·8
	R. albomaculata	7	6	3·4
	Notothenia elegans	7	5	2·8
	Iluocetes elongatus	6	1	0·6
	Careproctus falklandica	6	1	0·6
	Discopyge tschudii	4	1	0·6
	Leptonotus blainvilleanus	4	1	0·6
	Phucocoetes latitans	4	1	0·6
	Maynea brevis	4	4	2·2
	Xystreurys rasile	4	3	1·7
	Harpagifer bispinis	3	1	0·6
	Palinurichthys griseolineatus	3	3	1·7
	Sebastodes oculatus	3	3	1·7
	Pogonolycus elegans	2	2	1·1
	Melanostigma microphthalma	2	2	1·1
	Cataetyx messieri	2	2	1·1
	Palinurichthys caeruleus	2	2	1·1
	Raja multispinis	1	1	0·6
	Psammobatis extenta	1	1	0·6
	Muraenolepis microps	1	1	0·6
	M. orangiensis	1	1	0·6
	Notothenia macrophthalma	1	1	0·6
	Mancopsetta maculata	1	1	0·6
	Achiropsetta tricholepis	1	1	0·6

beds of kelp (*Macrocystis*, *Durvillea*, etc.) may extend out to 30 fm. and render any form of fishing difficult, though they certainly harbour many species of fish.

The trawl seems an adequate sampling instrument within the limits set by the mesh used. Hickling (1933, pp. 11–19) has given adequate demonstration of this, and our results with a closely allied species of hake (pp. 284–9) conform with his as closely as could reasonably be expected. Faulty hauls cannot prove absence or relative abundance, but have helped to prove presence of certain species on some occasions. The trawl cannot provide adequate data for pelagic species such as herring, or very small species such as some Zoarcidae. Immature specimens of some of the larger, more important species also escape through the meshes. This loss is most serious with the more slender forms, such as very young hake (especially males), immature *Macruronus*, *Micromezistius* and *Genypterus*. The fine-meshed nets attached to the back of the trawl caught enough of these to enable us to outline their probable distribution, but do not provide comparable quantitative data. Provided that these limitations are borne in mind, Table 2, which gives the total numbers of the species in 'Trawl + accessory nets', and their frequency of occurrence, helps to extend the outline of our general picture of the fish fauna begun by the first table.

The fish fauna of the Patagonian shelf is not rich in species, as the full list in Table 1 shows. In a preliminary account of the trawling surveys,[1] Gunther pointed out that it is less than one-third of the strength of the British list, and nearly twice as many species occur in the Gulf of Maine (Bigelow and Welsh, 1925). Apart from the numbers of species, there are big qualitative differences from the types of fish faunas known from other parts of the world. The marked predominance of the percoid group Nototheniiformes, with four families, seven genera and twenty-one species from the area of the surveys, and relatively large number of Zoarcidae with eleven species representing eight genera, are a most peculiar feature. Among elasmobranchs Rajidae show many species and remarkable diversity for an area where nearly all the known changes in environmental conditions are gradual. Dogfish are not common on the shelf, and the numbers of species of true codfishes (Gadidae) is small; in these features we see a great contrast to the fish faunas of northern Europe and of the New England states. Table 3, showing the relative strengths of some of the important groups in British seas, on the Patagonian shelf and in the Gulf of Maine, summarizes these points. The comparison between British and Patagonian fish faunas was first made by Gunther in the preliminary account mentioned above, and I have abstracted figures from Bigelow and Welsh (1925) for the Gulf of Maine to make the comparison wider.

Table 3. *Relative proportions of certain taxonomic groups in British seas, on the Patagonian shelf and in the Gulf of Maine*

	British seas	Patagonian shelf	Gulf of Maine
No. of spp.	350	95	173
Rajidae	5%	10%	3½%
Percomorphi	31%: No Nototheniiformes Zoarcidae 1 sp.	48%: Nototheniiformes 21 spp. Zoarcidae 11 spp.	27%: No Nototheniiformes Zoarcidae 3 spp.
Gadidae	6½%	3%	7%
Heterosomata	8%	5%	7½%

The Nototheniiformes are, of course, an essentially southern group, but it has further to be noted that most of the Patagonian species are distinct from the Antarctic ones; and the number of species common to other sub-Antarctic localities, such as the Antipodes, is small. The relations between the

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[1] 'A Fishery Survey of the Patagonian Continental Shelf' read before Section D of the British Association, July 1938.

Patagonian fish fauna and that of Kerguelen and Heard Island were dealt with by Regan (1914, p. 36), who treated the latter as a peripheral district of the Antarctic Zone. Norman (1937, p. 148), reviewing the question with more recent evidence, reached the conclusion that the dissimilarity between the fish faunas of the Kerguelen and Patagonian regions was not so great as Regan had supposed, and pointed to several pairs of species of the closest phylogenetic relationship from the respective regions. However, it is easy to demonstrate similar close relationship between Patagonian species and others from very widely remote regions, as we shall presently show. Norman himself, in a later work (1938, pp. 100 et seq.), summed up the present position in regard to this question with the statement: 'it is clear that, although the coastal fish fauna of the Kerguelen district shows certain features of resemblance to that of the Patagonian region and the Antipodes, its affinities are mainly with that of Antarctica.' This is precisely what one would expect from our latest knowledge of the hydrology of the regions concerned (Deacon, 1937).

In strong contrast to the marked differences between the Patagonian fish fauna and that of other regions, some of which have been shown in Table 3, several important and familiar species from better-known grounds can be 'paired-off' with Patagonian species closely allied to them. This feature was first made clear in Gunther's unpublished work, and was subsequently expanded by Norman (1937, p. 146), and by Gunther himself in his address to Section D of the British Association during the following year. These workers were concerned to show the parallels between allied British and Patagonian species, as an aid to general description of the fauna. I have attempted to widen the basis of this comparison with further parallels from the Gulf of Maine and from South Africa. Naturally there are fewer closely allied species from such widely diverse regions. South African waters are subtropical, though with low temperatures in the Benguela current, and the Gulf of Maine is a very specialized 'cold-temperate' area with exceptionally high summer temperatures due to the influence of the Gulf Stream. Nevertheless, I find these broad comparisons helpful in gaining an idea of the character of the Patagonian fish fauna, especially in conjunction with the roughly quantitative work to be described later. I therefore include them here in the hope that those who read this report may similarly be aided.

Table 4. *Closely allied species from the Patagonian shelf, British seas, the Gulf of Maine and South African seas*

Patagonian shelf	British seas	Gulf of Maine	South African seas
Myxine australis	*M. glutinosa*	*M. glutinosa*	*M. capensis*
Squalus lebruni	*S. acanthias*	*S. acanthias*	*S. acanthias*
Raja flavirostris	*R. batis*	*R. stabuliforis*	*R. batis*
Clupea fuegensis	*C. harengus*	*C. harengus*	—
C. arcuata	*C. sprattus*	—	—
Merluccius hubbsi	*M. merluccius*	*M. bilinearis*	*M. capensis*
Micromezistius australis	*M. poutassou*	*Microgadus tomcod*	—
Salilota australis	*Urophycis blennioides*	*U. tenuis* et spp.	—
Sebastodes oculatus	*Sebastes marinus*	*Sebastes marinus*	*Sebastichthys capensis*
Stromateus maculatus	—	*Poronotus triacanthus*	*Stromateus fiatola*

It is clear from this table that quite a number of Patagonian species have close relatives elsewhere, but when the quantitative aspect is taken into account we find that with the exceptions of the hake, *Micromezistius* and *Stromateus*,[1] the Patagonian species listed are relatively far less numerous than are their nearest counterparts on the better-known grounds we have considered. Thus the differences

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[1] Also the Falkland herring, but this could not be adequately sampled by the trawl.

between the Patagonian fish fauna and that of these better-known fishing grounds outweigh the resemblances, and if we are to succeed in describing the general facies of the Patagonian fauna by analogy with that of other regions it will be necessary to cast our minds still farther afield. The differences have already been summarized (in part) in Table 3. Four notable ones are: predominance of Nototheniiformes, the relative unimportance of Gadidae and of flatfish, and an absence of Salmonidae of useful size (which was not previously mentioned). In all these respects the Patagonian fauna differs markedly from that of better-known fishing grounds in the northern hemisphere. It is also most unfortunately true that relative scarcity and small size of flatfishes and Salmonidae are features common to all the other fishing grounds of the southern hemisphere. Consider, then, an area in the northern hemisphere which we have not yet taken into account—the North Pacific. If we allow ourselves to imagine this fauna without its two best fishes, salmon and halibut, what would be its remaining characteristics? Predominance of Scorpaenidae and allied families, especially Hexagrammidae (with *Ophiodon elongatus*, the cultus cod) and the Cottidae or sculpins. Herring would be important, but though Gadidae would be fewer than in other parts of the northern hemisphere they would still rank high. The relative importance of *Merluccius productus*, a true hake hitherto despised on that favoured coast, would be much enhanced.

Now Jordan (1905, vol. II, pp. 501 et seq.) has pointed to the close analogy which exists between the exclusively southern Nototheniiformes and certain families of the great group of mail-cheeked fishes which he calls Pareioplitae (including the Hexagrammidae, etc.). Of the Nototheniidae he remarks their 'general resemblances to small Hexagrammidae', and a little later he speaks of them as 'the antipodes of the Cottidae and Hexagrammidae; although lacking the bony stay of the latter, they show several analogical resemblances and have very similar habits', and again '...Harpagiferidae resemble sculpins even more closely'. To this may be added the close superficial resemblances between other (mainly Antarctic) Nototheniiform fishes (Bathydraconidae and Chaenichthyidae) and yet other families of the mail-cheeked fishes, such as Triglidae and Dactylopteridae. Without wishing to labour the analogy, which is shown only by some of the genera in the groups mentioned, it seems clear that the 'rock-fishes, etc.' of the North Pacific are a true biological counterpart of the Nototheniiform fishes of the Patagonian continental shelf, filling essentially the same 'ecological niche'.

Apart from purely analogical resemblances, it is possible to point to close phylogenetic relationships in the North Pacific, though perhaps they are fewer than the other parallels we have attempted to draw between the Patagonian fauna and that of other regions. *Hydrolagus colliei* and *Callorhynchus callorhynchus*, *Clupea pallasei* and *C. fuegensis*, *Microgadus* and *Micromesistius*, *Merluccius productus* and *M. hubbsi*, *Palometa simillima* and *Stromateus maculatus* are all closely related. *Sebastodes* is, of course, common to both regions, but whereas the genus is abundant in the North Pacific, the single Patagonian species is rare. The Nototheniidae clearly take the place of scorpaenids and their allies in Patagonian waters, as we have just seen.

If the analogy between the Pareioplitae (Scleroparei) and Nototheniiformes be admitted, it is clear that the Patagonian fish fauna bears a closer general resemblance to that found in the North Pacific than to the fauna of any of the other regions we have discussed. But in drawing the analogy we have to imagine a North Pacific fauna deprived of its two best fishes, salmon and halibut—a discouraging qualification with regard to prospects on the Patagonian grounds. There is a modest fishery for 'soles' (*Austroglossus*) at the Cape, for 'flounders' (*Rhombosolea* and *Ammotretis* spp.) in Tasmania, for 'lemon dabs and flounders' (*Pelotretis* and *Rhombosolea* spp.) in New Zealand, and for 'lenguado' (*Paralichthys* spp.) in South America (north of our area). These localities are all (hydrologically speaking) nearer to subtropical than to sub-Antarctic conditions, and in colder waters the scarcity of flatfishes of useful size is general throughout the southern hemisphere. Sizeable Salmonidae are also unknown in the southern hemisphere (apart from introduced trout) so that these two deficiencies are by no means peculiar to the Patagonian shelf. The most encouraging features, more apparent when the quantitative data are considered, are that a true hake is common on the Patagonian grounds, that minor quantities of another merlucciid, a butterfish or pomfret, and lesser numbers of other species are all good eating, and that there is a Falkland herring which may prove to be of real value. Though our gear was admittedly unsuitable for sampling this last species, its abundance is placed beyond doubt by the frequency with which it was observed in the stomachs of larger piscivorous species.

The Patagonian fish fauna has certain species in common with other southern hemisphere localities, and it may be thought that in attempting to draw descriptive parallels it would have been better to turn to these rather than to the northern hemisphere. I did not attempt this because the essentially subtropical conditions of the other southern localities leads to the prevalence of various percoid groups very different from the Nototheniiformes, so that although New Zealand for example has some species in common with Patagonia, and a few others closely allied, the general character of the vastly richer fish fauna is altogether different from that of the Patagonian one. This remark applies with even greater force to the fish faunas of Southern Australia and South Africa. It is mainly in the scarcity or absence of certain groups, as Salmonidae and Gadidae, that the fish faunas of these areas can be said to show any resemblance to that of Patagonia. The extent to which we are forced back to the northern hemisphere for closer parallels is a measure of the extent to which meteorological factors, chiefly temperature, determine the conditions of life in the sea.

It is a striking fact that a true hake is found in each of the regions we have discussed: *Merluccius merluccius* to the west of Great Britain, *M. bilinearis* in the Gulf of Maine, *M. productus* on the Pacific coast of North America, *M. capensis* off South Africa, and *M. hubbsi* on the Patagonian shelf. Three of these five species are already heavily exploited: prior to the war Hickling's work had shown (1935*a*) that the European stock was being overfished, while in the last twenty years *M. bilinearis* has risen from the status of 'rubbish' to the New England fishermen, to the highest place among the frozen fish products of the eastern states. Moreover, only half the catch is frozen. *M. capensis* forms a third of the catch of the trawling industry at the Cape, where large quantities of it are salted and dried. *M. productus* is not yet sought after. In a region where better fish are still abundant the softness of its flesh makes it unpopular. In less favoured localities the other species of hake, probably little better in this respect, are valued and are successfully marketed, owing to improved methods of preservation and storage. This is especially true of *M. bilinearis*, half of the catch being sold inland in the form of frozen fillets, etc. This species is the one most nearly allied to the Patagonian *M. hubbsi*. Such small quantities of the last named as are caught by the small trawlers which operate from the mouth of the River Plate, well to the north of our area, fetch prices well up to the average in the Buenos Aires market.

In summarizing the points dealt with in this section of the report, we may say that the fish fauna of the Patagonian shelf is peculiar in quality and in the small number of species to be found there. The number of potentially valuable forms is small too, and their quantity not encouraging, but hake are moderately abundant. The nearest parallel among fish faunas of better-known regions is probably that with the North Pacific, but with important reservations detailed above. There is also some resemblance to the conditions found on the hake grounds to the west of the British Isles.

DISTRIBUTION AND GENERAL NOTES ON THE SPECIES

PETROMYZONIDAE

A specimen of *Geotria australis* Gray was obtained by Dr Hamilton in the Falkland Islands, but none was taken during the trawling surveys. Possibly the marine phase of the life history does not extend far beyond the littoral zone, but the general distribution of the species appears to be circumpolar in sub-Antarctic waters, and even extends to subtropical waters in Australia.

MYXINIDAE

Three 'good' species of the genus *Myxine* were recognized by Norman (1937, pp. 4–7) from the Patagonian region. One of these, *M. tridentigera* Garman, was not obtained by the Discovery Committee's ships. It is known only from the unique holotype from Magellanes. Four specimens of *M. affinis* Günther were taken at St. WS 582 in a dip-net, but none from the area of the trawling surveys. The remaining species, *M. australis* Jenyns, seems to have a much wider distribution. It is common at the Falkland Islands, where specimens have been collected by Bennett and Hamilton, on both coasts of South America and particularly in the Magellan channels. A specimen has also been collected by Hamilton at the South Shetlands, a fact of exceptional interest, as I am not aware of any other record of a cyclostome being taken south of the Antarctic convergence. Details of our observations on the distribution of this species are:

Myxine australis Jenyns. I: in 'Trawl+accessory nets'

Station	Mean depth m.	Numbers	Station	Mean depth m.	Numbers
WS763[1]	84	1	*WS812 I*	53	1
WS789	94	7	*WS833*	34	3
WS792 A	104	1	*WS834*	32	1
WS797C	112	10			

II: in 'Other gear'

Station	Mean depth m.	Numbers etc.	Station	Mean depth m.	Numbers etc.
Port Stanley (J. E. H.)	?	1	**WS856**	104	1 in BTS
Salvador waters (A. G. B.)	?	1	*WS871*	338	1 in BTS
Port Stanley (A. G. B.)	?	1	*WS873*	**93** (–0)	1 in NR
WS835	15	6 in BTS	*WS878*	121 (–0)	5 in NR
WS836	64	1 in BTS			

Thus although the majority of specimens were captured in shallow inshore waters, the species has been taken below 300 m., and at four of the remaining fifteen stations the depths slightly exceeded 100 m. It also extended much farther north on the east coast than the other species, a considerable concentration being found off the Golfo san Jorge. The other records are mostly grouped much farther south, off the mouth of Magellan Straits and the north-east coast of Tierra del Fuego. There is no obvious reason for such a discontinuous distribution, but the gear used is obviously far from efficient for the capture of such slender organisms, and as it was not obtained in large numbers anywhere, insufficient sampling is quite possibly the sole cause. Apart from the probability that *M. australis* will be found to attack useful fish, especially those that come well inshore, it is of no potential economic significance.

LAMNIDAE

Cetorhinus maximus (Gunner). No basking sharks were seen or captured by our ships within the trawling area. Norman (1937, p. 7) gives the details known concerning one washed up in East Falkland and quotes Hamilton's observations on another seen off Cape Dolfin in 1936. He notes that it may prove to be distinct from the common species of the northern hemisphere.

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[1] See pp. 250–1 for distinction between 'northern', 'intermediate', and 'southern' regions.

SCYLIORHINIDAE

Scyliorhinus (*Halaelurus*) *bivius* (Smith) was not obtained at the trawling stations. Five specimens were obtained with 'Other gear' at three stations in the western channels.

SQUALIDAE

Squalus lebruni (Vaillant) is very close to the familiar *S. acanthias* of the northern hemisphere. From the material at Norman's disposal up to 1937 he judged that 'there appears to be only one species of Spotted Spiny Dogfish in the southern hemisphere' (Norman, 1937, pp. 9–10). Dogfish are rare on the Patagonian grounds, in strong contrast to their abundance in European seas. This would be a helpful feature if long-lining for any of the more useful species were found practicable in the future. They could of course be utilized in the same way as the northern species, but our records suggest that they are far too scarce ever to form an appreciable part of the catch of a commercial fishery. *S. lebruni* was not taken in 'Other gear'; records of its occurrence in the trawl are:

WS90	1 of 67 cm. length.	**WS791B**	1 of 66 cm., 1150 g.
WS94	3 of 61, 62 and 64 cm.	WS797C	1 of 66 cm., 1300 g.
WS218	1 of 64 cm.	**WS853**	1 of 65 cm., 1200 g.

These scanty records suggest that the species probably ranges over the whole of the shelf in summer, and that it commonly attains a length of 2 ft. and a weight of some 2½ lb.

SQUATINIDAE

Squatina armata Philippi was not taken by the expedition, but Norman (1937, pp. 10–11) provisionally identified two Argentine specimens with this Chilean species, so that it may possibly occur within the area of the trawling surveys.

TORPEDINIDAE

Discopyge tschudii Heckel. This species is known to range far north on both sides of South America, but was only once taken by us:

WS776 103 m. 4 ♀♀ specimens

RAJIDAE

The general distribution and depth relations of the species of this family taken by us have been summarized, after the notes on individual species, in the form of tables and a figure dealing with all the Elasmobranchs taken in the trawl (Fig. 18, p. 276). Measurements of disk width and many weights were recorded, but owing to the scarcity of most of the species they are not sufficiently numerous to repay statistical treatment. The individual records therefore refer only to numbers of specimens taken. It is noteworthy that disk-width measurements made by Gunther and his colleagues in the field show discrepancy with some of Norman's (1937) records, owing no doubt to shrinkage of preserved material.

Raja flavirostris Philippi. This species is morphologically very closely related to *R. batis* of British seas and *R. stabaliforis* of New England. It was widely distributed over the shelf in small numbers, rather more frequently in the northern region than elsewhere. In common with *R. magellanica* it favoured shallower waters than other members of the genus (Fig. 18), in spite of our difficulties in sampling such a large area we can claim to have revisited most parts of the shelf at least three times, so that it is a remarkable fact that this skate was never found in the same place twice. Evidently it must roam widely over the plain of the shelf (Fig. 8), and such behaviour is precisely the opposite of that which Steven (1936) found in *R. clavata*. The young and adolescent stages of the thornback seem nearly stationary, while even the migration of adults (Steven, 1932) is probably on a small scale.

R. flavirostris was taken in the 'Trawl + accessory nets' at twenty-four stations as shown below. None was captured with 'Other gear':

WS77	1	**WS763**	1	WS796B	1
WS79	2	**WS765**	1	WS797C	8
WS95	1	**WS789**	1	WS810	1
WS214	1	**WS790A**	1	*WS815*	3
WS217	3	**WS790B**	1	*WS816*	1
WS233	1	**WS791B**	1	*WS817B*	1
WS236	1	**WS792B**	1	*WS834*	2
WS245	1	**WS793**	3	WS857	1

Of the twenty-eight individuals which were sexed, there were fifteen males and thirteen females; sex ratio 53·5% ♂♂.

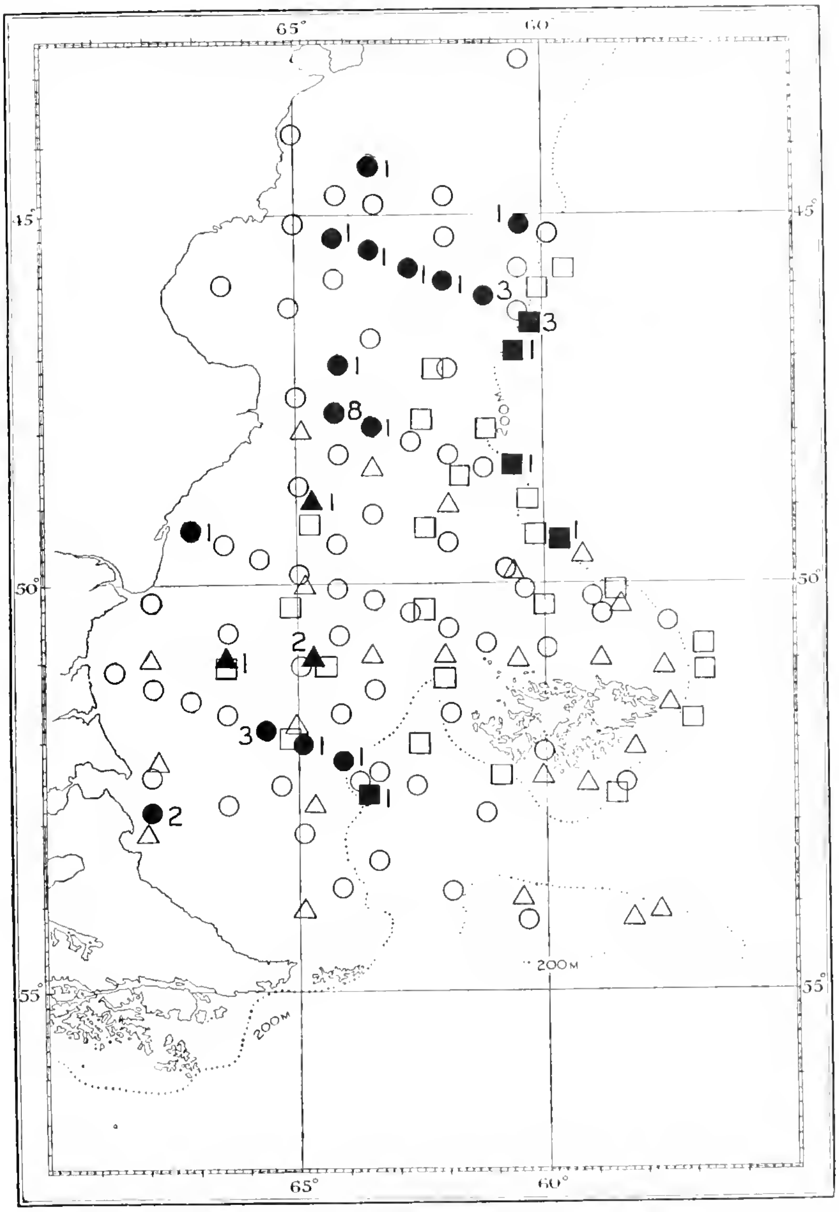

Fig. 8. Distribution of *Raja flavirostris*. First survey: triangles; second survey: squares; third survey: circles; negative observations left blank.

Raja doello-juradoi Pozzi. Our captures of this species were most frequent in the southern region, and it was there that the only rich haul (of fifty-two specimens) was obtained, but isolated captures were recorded far to the northward all along the edge of the shelf. It is a deep-water species found almost exclusively at or over the shelf edge (Fig. 18). Fig. 9, which shows the spatial distribution, also brings this point out very clearly. *R. doello-juradoi* is the most numerous of a small group of rays which we found only in deep water, especially in the Falkland trough. The other three species were all new to science. *R. doello-juradoi* was taken only in 'Trawl + accessory nets', never in 'Other gear':

WS98	1	*WS245*	52	WS795	2
WS215	1	*WS246*	1	WS817B	1
WS218	4	*WS783A*	1	WS820	1
WS237	1	WS794	1	WS851	2

Of the sixty-eight specimens thirty-eight were males and thirty females; sex ratio 55·9% ♂♂.

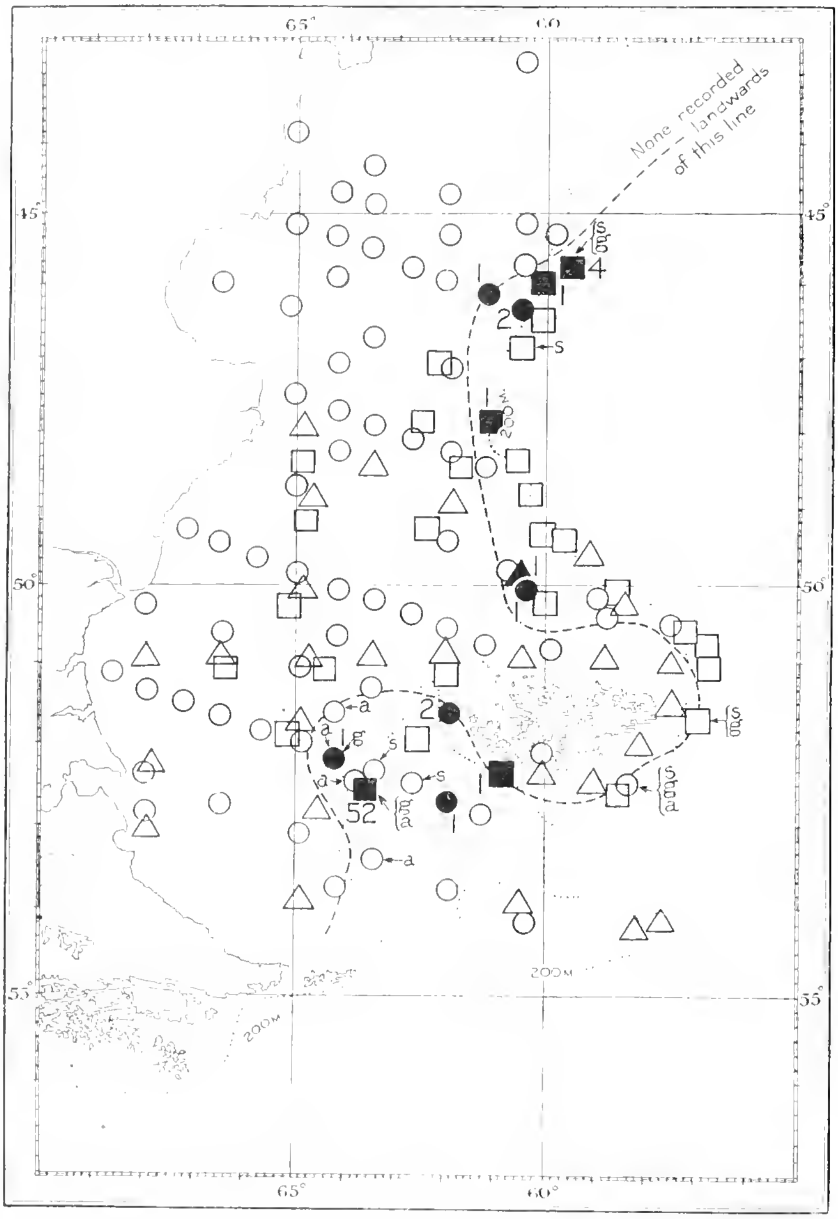

Fig. 9. Distribution of *Raja doello-juradoi* and the other deep-water rays. First survey: triangles; second survey: squares; third survey: circles; negative observations left blank. Numbers refer only to *R. doello-juradoi*. *g* = *R. griseocauda*; *s* = *R. scaphiops*; *a* = *R. albomaculata*; positive records only.

Raja macloviana Norman. The general spatial distribution of this species (Fig. 10) is very similar to that of *R. doello-juradoi*, but a consideration of its distribution with depth shows that a higher proportion of *R. macloviana* was taken just on the shelf, instead of just 'over the edge'; hence the dumbbell-shaped distribution shown in Fig. 18. It is probable that this is caused by a migration to deeper water with increasing size (and age), but our data are too few to demonstrate this clearly. A more pronounced depth relation of the same type shown by *R. brachyurops*, a more common species presently to be discussed, is almost certainly due to this cause, and when plotted in similar fashion shows a more sharply angled polygon of the same basic type. *R. macloviana* was taken only in the 'Trawl + accessory nets', never in 'Other gear':

WS80	1	WS217	3	WS245	1
WS87	1	WS218	4	WS813	1
WS95	1	WS225	4	WS817A	1
WS109	1	WS236	3	WS817B	2

Of twenty-two specimens ten were males and twelve females; sex ratio 45·4 % ♂♂.

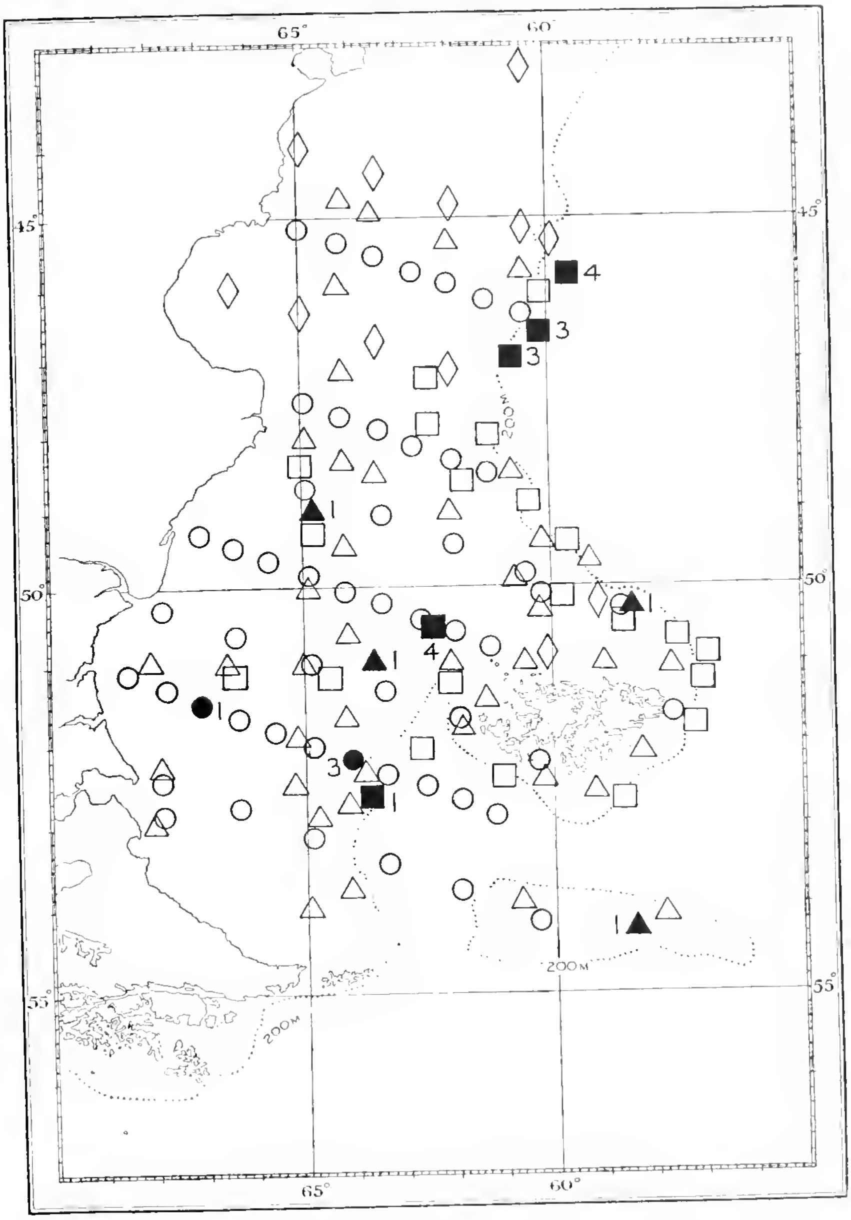

Fig. 10. Distribution of *Raja macloviana*. Spring: diamonds; summer: circles; autumn: triangles; winter: squares; negative observations left blank. *Note*. Symbols here refer to seasons, and not to surveys.

Raja magellanica Steindachner. All our captures of this species were made in the intermediate and southern regions, and all but two of them definitely on the shelf. The spatial distribution is shown in

Fig. 11, and the characteristically shallow depth distribution can be seen in Fig. 18. One specimen was secured with the small beam trawl, all the others with 'Trawl + accessory nets'. It will be seen that the distribution is almost co-extensive with that of another shallow-water species, *Psammobatis scobina*, but *Raja magellanica* was found slightly farther south at some points, and tends to occur with greater *relative* frequency in the southern region. Thus of the totals of the two species, less than 30% of the *Psammobatis* were from the southern region, but 48% of the *Raja magellanica* were taken there. Although the observed sex ratio of this species was practically 'normal', there was a hint of segregation into a unisexual shoal at one station. This is a marked feature in some of the more abundant elasmobranchs of British seas and may then lead to a most anomalous *apparent* sex ratio, especially in commercial landings, which may be further distorted by greater value and ease of capture

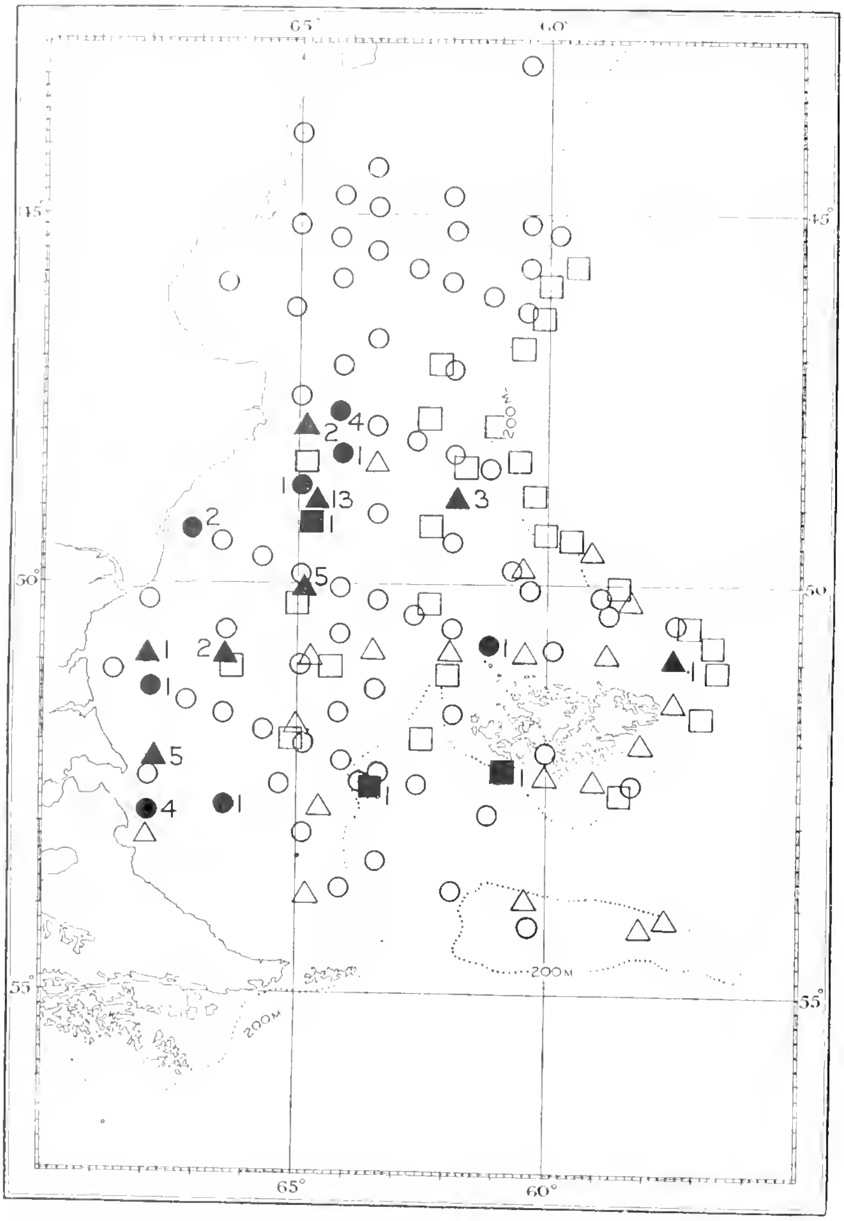

Fig. 11. Distribution of *Raja magellanica*. First survey: triangles; second survey: squares; third survey: circles; negative observations left blank.

of the (usually) larger females, and by close packing of the schools of the latter, especially when gravid (Ford, 1921, pp. 483–5; Hickling, 1930*a*, pp. 537–8; Steven, 1933):

WS72	1	WS96	2	WS810	2
WS77	2	WS108	3	*WS811 H*	1
WS78	1	WS223	1	*WS834*	4
WS90	5	*WS245*	1	*WS837*	1
WS91	1	*WS246*	1	WS862	1
WS92	2	WS787	1		
WS94	5	WS797C	4	WS861(BTS)	1
WS95	13	*WS802 A*	1		

Of fifty-three specimens, twenty-six were males and twenty-seven females; sex ratio 49·1 % ♂♂.

Raja multispinis Norman. The holotype of this new species was taken in the trawl at St. *WS851* in the southern region, depth 221–197 m.

Raja scaphiops Norman. Two specimens were obtained in the north, in deep water 'over the edge' in winter. Five specimens were subsequently secured from four southern stations, one on the edge and three in deep water (Figs. 9, 18). This species was taken only by the trawl: **WS218** (2), *WS250* (1), *WS818 A* (1), *WS819 B* (2), *WS824* (1).

Raja albomaculata Norman. Seven specimens of this new species were trawled at six southern stations. Two of these were on the edge of the shelf, the others all in deep water. None was taken in 'Other gear'. Only the positive records are indicated in Fig. 9, along with the other rare deep-water species. The negative records for the more common *R. doello-juradoi*, shown in the same figure, can of course be taken as negatives for the others provided that they are sufficiently remote from the appropriate positive symbols. It has not been easy to achieve this where more than one species occurred at one of several closely spaced stations. Specimens of *R. albomaculata* were obtained at the following stations:

WS245	1	*WS824*	1	*WS868*	1
WS817 B	1	*WS839*	2	*WS875*	1

Raja brachyurops Fowler. This was the commonest ray of the trawling surveys. It occurred with moderate frequency in all three regions; most frequently, in relation to the total of hauls in which it might have been taken, in the intermediate region. Most of the richer hauls were in the southern region, and the total of numbers taken in each region showed marked and progressive diminution towards the north (Fig. 12, Tables 7 and 8).

When the data relating to the depth distribution of this species are treated as a whole, we see that it had a wide range extending into deep water over the edge of the shelf; but the depth-frequency polygon shows two maxima, one over the edge and the other in much shallower water on the shelf (Fig. 18). The distribution charts (Fig. 12) show that this may be due to seasonal movement on to the shelf in summer and down into deep water in winter. Such a movement would be analogous to that known in some European species, e.g. *R. clavata*, *R. radiata* and *R. fullonica*, which show (at least in the adult stages) a movement into the North Sea in summer, but are found chiefly in deeper water to the north and west at other seasons (Meek, 1916, pp. 41–3). More recently, Steven (1932, p. 20) has shown that *R. clavata* appears to hatch out in shallow water, that the dispersal of young and adolescent fish to greater depths is slow (Steven, 1936), but that in the English Channel adults are rarely found inshore except in spring just prior to the deposition of eggs.

If an analogous movement takes place in *R. brachyurops* we should expect our deep hauls to contain a higher proportion of large individuals than the shallow hauls, taking the year as a whole, though the trend might be masked by a few good catches of adults in shallow water during their migration.

Disk-width frequencies of all records from the two depth categories, shown as percentages in Fig. 13, clearly support the possibility of such a migration: individuals of the greater widths were more frequent in the deep hauls and the smaller individuals in the shallower hauls. About the main mode, however, the deep hauls show considerably greater frequencies, so that the difference is less well defined than could be wished, while the adverse factor of some migrating adults being taken on the shelf is unavoidable by this method of array.

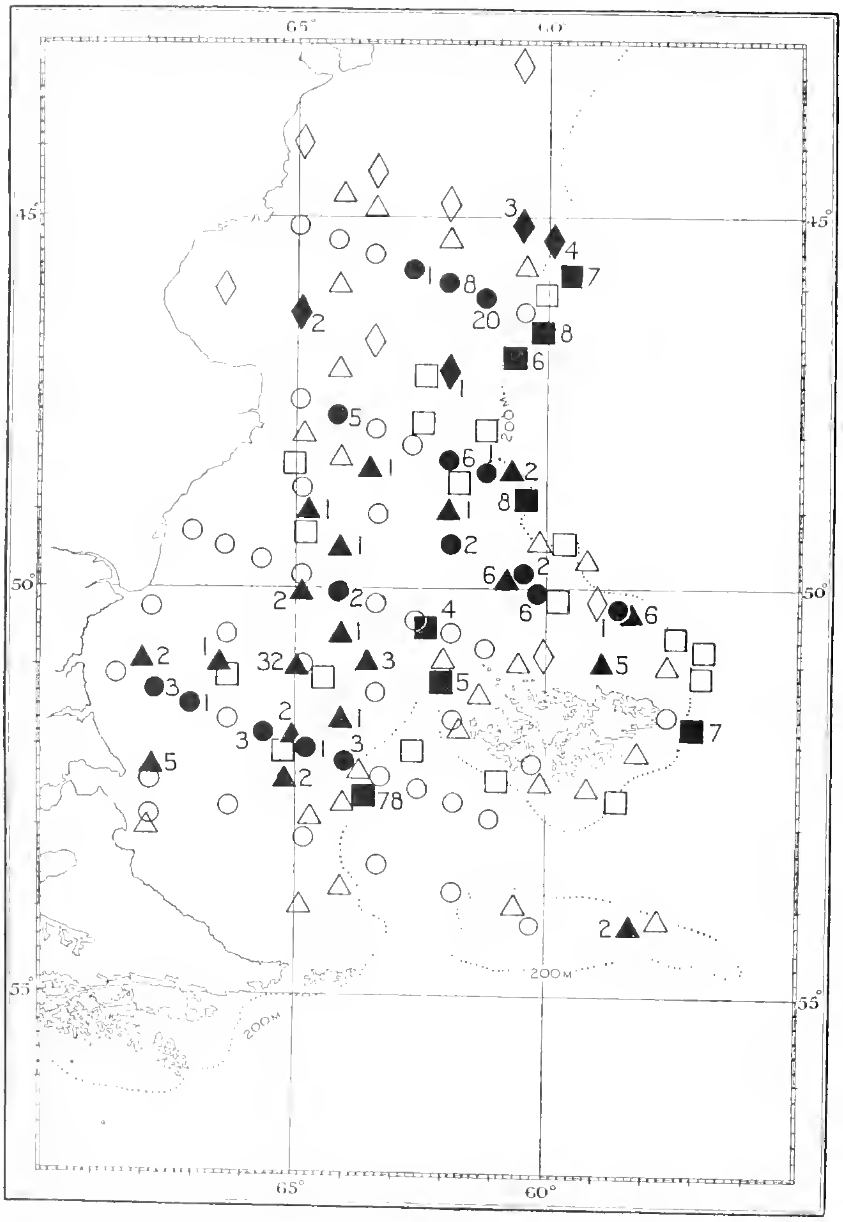

Fig. 12. Distribution of *Raja brachyurops*. Spring: diamonds; summer: circles; autumn: triangles; winter: squares; negative observations left blank. *Note*. Symbols here refer to seasons, and not to surveys.

Fig. 13 gives just a hint of possible submodes at roughly 4–5 cm. intervals that may indicate year classes. Trial freehand curves drawn from grouped data by Buchanan Wollaston's (1929) method show some support for this view, which seems reasonable from the annual increment of 6 cm. established by Steven (1936, p. 614) for *R. clavata*, which is a larger species. Our data are not numerous enough for us to regard the 4–5 cm. increment for *R. brachyurops* as more than a possibility.

Although this was the commonest ray in our area, there were only 143 measured individuals (of over 10 cm. width) on the shelf, and 115 over the edge, so that bigger sampling would almost certainly give a better result. The wide dispersion, leading to large values for σ, renders the difference between means of some 2·5 cm. statistically insignificant. Once the probability of migration was established, however, numerous methods of array according to season could be undertaken without fear of waste of effort; and these seem (to me) to establish beyond all reasonable doubt the fact of migration on to the shelf in summer and over the edge into deep water in winter.

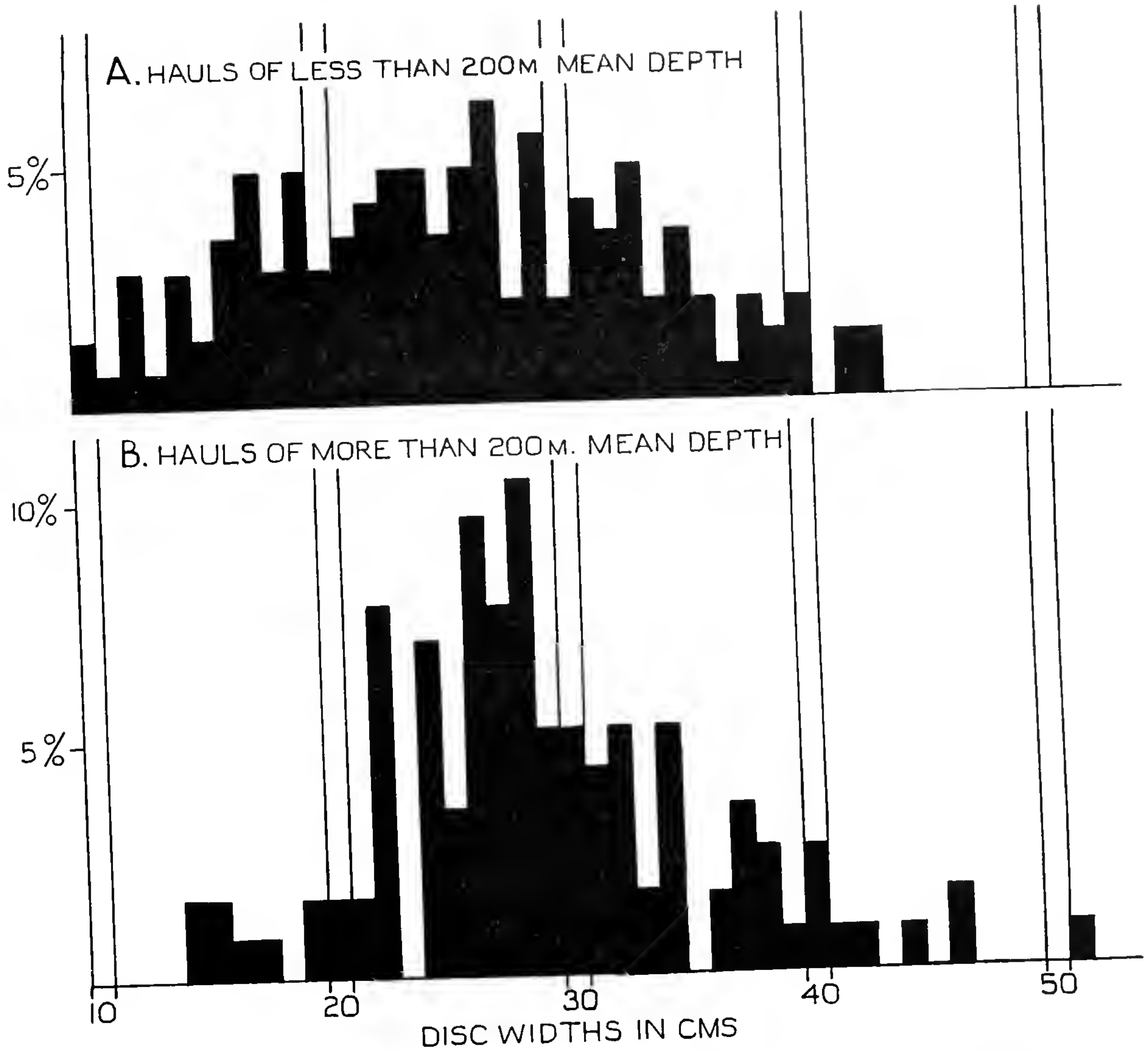

Fig. 13. Size-frequency distribution (percentage at each cm. of disk-width) of *Raja brachyurops* in hauls (A) on the shelf, and (B) 'over the edge'.

Fig. 14 shows that whether we consider total abundance of fish caught at each season in the two depth categories, or frequency of occurrence, the same result is arrived at: the species is relatively more abundant on the shelf in summer and autumn, and over the edge in winter. Spring appears to be a transition period with two sharply separated depth maxima, in ideal conformity with our thesis; but it must be confessed that the number of observations we have for that season are inadequate, and the conformity accidental. The data of Fig. 14 are accordingly tabulated here in full.

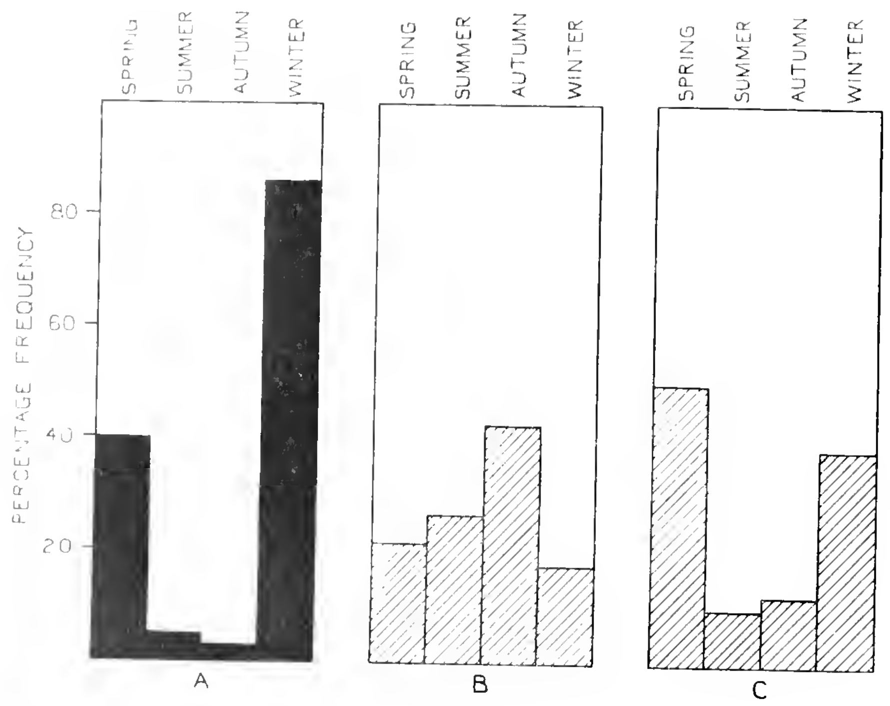

Fig. 14. A. Seasonal variation in total abundance of *Raja brachyurops* 'over the edge' (>200 m.) black, and on the shelf (<200 m.) white; also seasonal variation in its frequency of occurrence B on the shelf, and C 'over the edge'.

Table 5. *Full data relating to* Raja brachyurops *plotted in Fig.* 14

Season	On the shelf, depths less than 200 m.			Over the edge, depths more than 200 m.		
	No. of individuals		% of total caught in each season	No. of individuals		% of total caught in each season
Spring	6		60	4		40
Summer	62		95	3		5
Autumn	74		97	2		3
Winter	17		14	106		86
	No. of hauls	No. positive	% positive	No. of hauls	No. positive	% positive
Spring	14	3	21·4	2	1	50
Summer	65	17	26·2	10	1	10
Autumn	42	18	42·9	8	1	12·5
Winter	17	3	17·6	13	5	38·5

Separate depth-frequency polygons of the type used for summarizing the main features of depth distribution of all elasmobranchs may also be plotted for *R. brachyurops* at each season, as in Fig. 15. This presents the evidence of seasonal migration even more clearly.

Very good evidence that the young of *R. brachyurops* are hatched on the shelf can be obtained by considering our records of captures of minute post-embryos and yearlings less than 10 cm. wide. Their seasonal distribution also is so circumscribed as to establish the approximate hatching period, and they are accordingly tabulated in full (Table 6).

It can be seen that all but two of the twenty-two very small specimens were caught between 30 March and 4 May, although more than a hundred observations were made at other seasons. Of the exceptions, the 9 cm. individual in October was presumably a late-hatched survivor of the previous

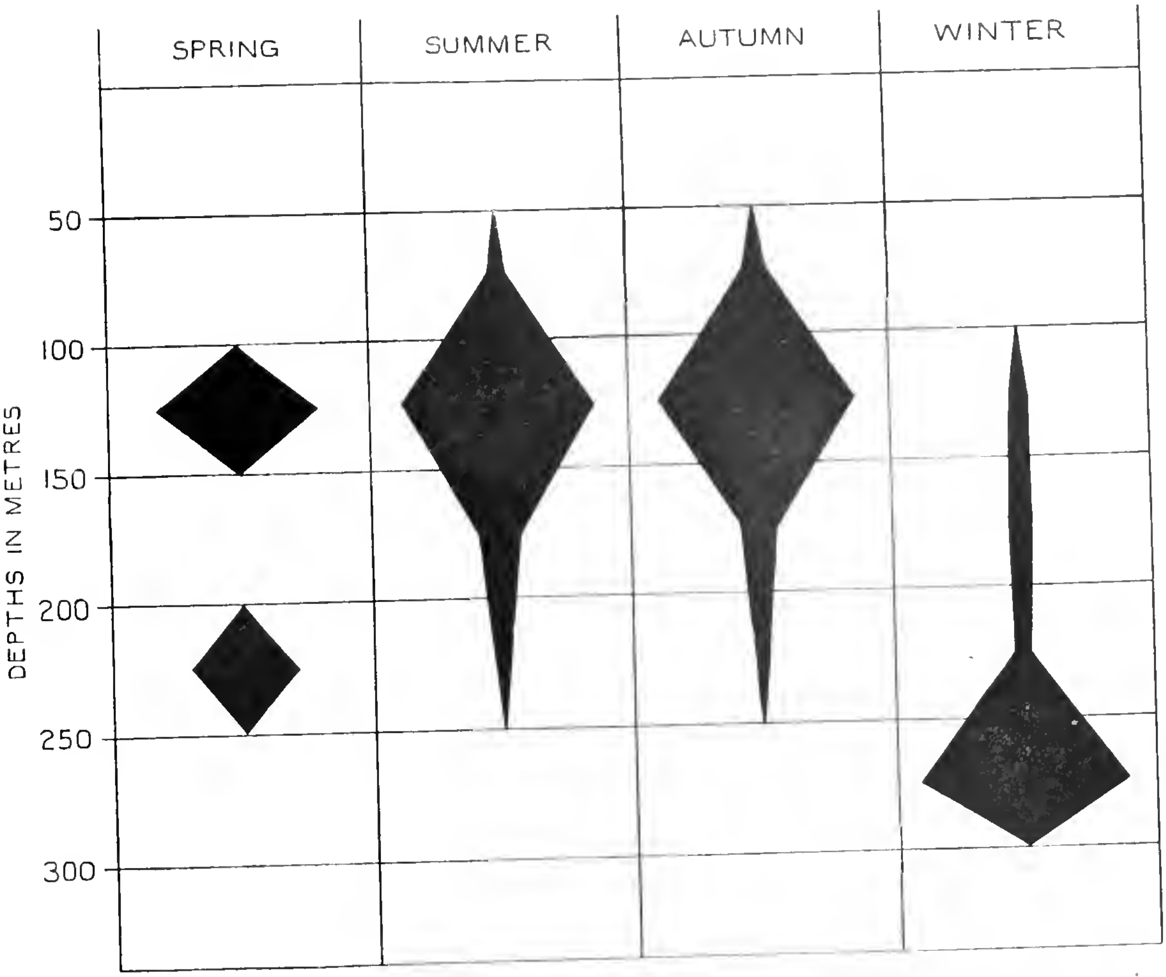

Fig. 15. Seasonal variation in depth distribution of *Raja brachyurops*. The widths of the polygons are proportional to the percentage depth-frequency distribution when the observations are graphed in 50 m. classes.

Table 6. *Captures of* Raja brachyurops *less than* 10 *cm. wide*

Station	Date	Numbers, size	Depth, gear
WS87	3. iv. 27	1 of 4 cm.	111 m. OTC (+N-T)
WS90	7. iv. 27	1 of 5 cm.	81 m.
WS94	16. iv. 27	1 of <5 cm.	118 m.
WS95	17. iv. 27	1 of <5 cm.	108 m.
WS109	26. iv. 27	3 of <5 cm.	145 m.
WS765	17. x. 31	1 of 9 cm.	115 m.
WS797	20. xii. 31	1 of 5 cm.	110 m.
48	3. v. 26	2 of 7·5 cm.	110 m., OTL
51	4. v. 26	1 of 7 cm.	115 m., DLH
51	4. v. 26	9 of 4(5)–9 cm.	110 m., OTL
WS867	30. iii. 32	1 of 5 cm.	148 m., BTS

year's brood, leaving a single anomalous observation in December. It seems almost certain that the eggs are deposited on the shelf in summer, and hatch in late summer or early autumn. The effective mean depth of these records is 116 m., with $\sigma = 15{\cdot}4685$. The effective mean depth of all the hauls in which *R. brachyurops* was taken is 194 m. with $\sigma = 78{\cdot}2598$. The difference d between these means is 78 m., and

$$\sigma_d = \sqrt{\frac{\sigma_{M_1}{}^2}{N_1} + \frac{\sigma_{M_2}{}^2}{N_2}} = 5{\cdot}7644,^*$$

---

* $N_1 = 274$.

Hence $d/\sigma_d = 13{\cdot}5$, and the difference, which indicates that the smallest individuals were found almost entirely near the upper limits of the depth range of the species, is very strongly significant. From this it appears that the summer migration of *R. brachyurops* on to the shelf is a breeding migration, particularly when we remember that nearly all the very young specimens have been secured in the autumn, when the movement towards shoal water of the species as a whole appears to be at its height.

The sex ratio of *R. brachyurops* seemed to be remarkably constant whatever grouping of the data was adopted. For all specimens whose sex was recorded it worked out at 47·7% males. There are indications that shoaling is more marked towards the end of the year, but large schools segregated according to sex, such as are known to occur in some European species, were not encountered:

WS73	5	*WS225*	4	**WS792A**	8
WS77	1	WS234	8	**WS793**	20
WS78	2	WS236	6	WS797B	1
WS79	32	*WS239*	5	WS797C	4
WS80	3	*WS245*	78	WS800B	6
WS87	2	*WS250*	7	WS801	1
WS90	5	**WS765**	3	*WS806*	2
WS92	2	**WS772**	4	*WS811H*	3
WS94	2	WS774	1	*WS813*	1
WS95	1	WS776	2	*WS815*	3
WS97	1	*WS782A*	1	*WS816*	1
WS98	6	*WS783A*	5	*WS817B*	3
WS108	1	*WS783B*	1	WS864	1
WS109	6	WS784	2	*WS866*	1
WS214	2	WS785B	2	*WS868*	1
WS217	8	**WS791B**	1	*WS874*	2
WS218	7				

In 'Other gear':

48	2 (in OTL)	*51*	12	*WS867*	1
51	2 (in DLH)	*WS865*	2		

Raja griseocauda Norman. Eight specimens of this new species were trawled: two at a deep northern station, two at a deep intermediate station, and one at each of four southern stations, three of which were in deep water and one on the shelf edge. Its distribution is much like that of *R. scaphiops*. It seems to be one of a group of uncommon deep-water rays: *R. doello-juradoi*, *R. scaphiops*, *R. griseocauda* and *R. albomaculata*, that occupy an ecological position in the Patagonian fauna similar to that of *R. falsavela*, *R. hyperborea* and *R. oxyrhyncha* to the north-west of the British Isles (Meek, 1916). The scanty distributional data for *R. griseocauda* are shown in Fig. 9, and the depth records are summarized along with those for the other species. None was taken in 'Other gear':

WS218	2	*WS245*	1	*WS817B*	1
WS236	2	*WS250*	1	*WS824*	1

Psammobatis extenta (Garman). A single specimen trawled at St. **WS788B** in the northern region is assigned by Norman (1937, pp. 28–9) to this species. Previous records were mostly from the Brazilian coast south of Rio de Janeiro, suggesting that the area we surveyed is south of the normal range of the species.

Psammobatis scobina (Philippi). Except *Raja brachyurops*, this was the most abundant elasmobranch we found during the trawling surveys. It was most definitely a species of the shelf, and was found in fair numbers closer inshore than any of the other shallow-water rays. (The slightly shallower 'effective mean depth' of *R. magellanica* is not significant, and doubtless is due merely to insufficient sampling of that less common species.) *Psammobatis scobina* was rare in the northern region, and relatively most abundant in the intermediate region, especially close inshore off Puerto Deseado and Puerto san Julian. It was fairly plentiful in the southern region also, but was only twice recorded south of the entrance to Magellan Straits, well offshore near the shelf edge. None was found to the south of the Falkland Islands. Fig. 16 shows the regional distribution, while the depth data are summarized along with those of all the elasmobranchs in Fig. 18 and Table 9.

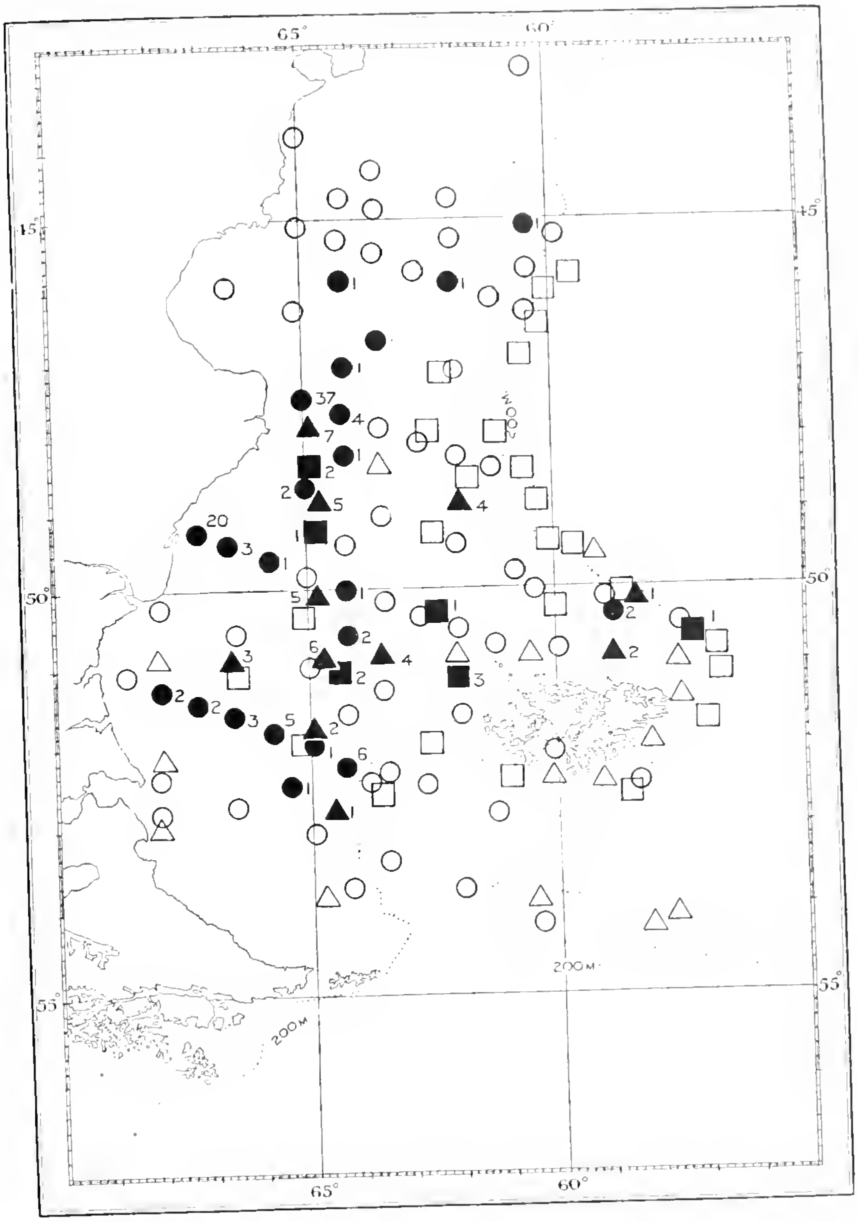

Fig. 16. Distribution of *Psammobatis scobina*. First survey: triangles; second survey: squares; third survey: circles; negative observations left blank. *Note.* Symbols here refer to surveys, and not to seasons.

The sex ratio observed in this species—67% males—is abnormal. It seems to be due to a tendency towards unisexual shoaling, and mere chance that we happened on more of the segregated males than females. Among European rays in which this habit is known it is the female shoals that are usually sampled to excess. It can be seen from the sex records that, of the two moderately rich hauls of this species we obtained, one was entirely male, while in the other the proportions of the sexes were precisely equal. It may be noticed that the total of individuals used in considering depth relations of *Ps. scobina* does not tally with that used to determine the sex ratio. This is because the three records from 'Other gear', and two others at which there was some doubt as to the depth logged, have been excluded from the former:

WS73	2: 1 ♂, 1 ♀	*WS243*	2 ♀♀	*WS813*	2 ♂♂
WS77	3: 1 ♂, 2 ♀♀	**WS765**	1 ♂	*WS814*	3: 1 ♂, 2 ♀♀
WS79	6: 3 ♂♂, 3 ♀♀	WS775	1 ♂	*WS815*	5: 2 ♂♂, 3 ♀♀
WS80	4: 1 ♂, 3 ♀♀	*WS782A*	2 ♀♀	*WS816*	1 ♀
WS91	1 ♀	WS786	1 ♀	*WS817A*	4 ♀♀
WS92	2 ♀♀	WS787	2 ♀♀	*WS817B*	2 ♀♀
WS94	5: 4 ♂♂, 1 ♀	WS792A	1 ♂	WS855	1 ♂
WS95	5, all ♂♂	WS796B	1 ♂	WS857	1 ♂
WS96	7: 6 ♂♂, 1 ♀	WS797B	4 ♀♀	WS862	1 ♂
WS108	4: 3 ♂♂, 1 ♀	WS797C	37, all ♂♂	WS864	1 ♂
WS109	1 ♀	*WS806*	1 ♂	*WS866*	2: 1 ♂, 1 ♀
WS222	2 ♂♂	WS808	1 ♂	*WS868*	2 ♂♂
WS223	1 ♂	WS809A	2: 1 ♂, 1 ♀	*WS874*	1 ♂
WS225	1 ♂	WS809B	1 ♀	WS856	1 ♂ (in BTS)
WS229	1 ♂	WS810	20: 10 ♂♂, 10 ♀♀	WS861	1 ♂ (in BTS)
WS239	3: 2 ♂♂, 1 ♀	*WS811H*	2: 1 ♂, 1 ♀	*WS865*	1 ♂ (in BTS)

Psammobatis microps (Günther) was not taken by the expedition's ships, but it is known from the mouth of the Plate and may occasionally range as far south as the northern part of the area we surveyed.

CHIMAERIDAE

Callorhynchus callorhynchus (Linnaeus). Our records of this species show that it was very definitely confined to the warmer inshore waters in our area. Most of our specimens were taken in the northern region, in spring. Single records in the intermediate region (autumn) and in the southern region (late summer, coincident with maximum temperatures for the year) suggest the possibility of a N → S → N migration along the coast. The distribution is shown in Fig. 17, and the depth relations in Fig. 18. *Callorhynchus* occurred in the trawl only, none being taken in 'Other gear'.

Norman (1937, pp. 35–6) has shown that Garman's (1904, 1911) distinctions between two 'species' of *Callorhynchus* on either side of South America cannot be maintained. *C. smythii* Bennett, 1839 should be regarded as a synonym of *C. callorhynchus* (Linnaeus), 1758. Norman further stated that 'It is probable that the examination of an adequate series of specimens would show that the nominal species *capensis*, from South Africa and *milii*, from Australia, Tasmania and New Zealand, are nothing more than varieties of *C. callorhynchus*'. Careful study of Garman's keys inclines one to agree. All the external characters, such as the relative extent of various fins and so forth, given as diagnostic by Garman, show complete overlapping. Most of them were exhibited within the limits of our own series of *C. callorhynchus*. They would be better described as agnostic characters. One is left with the modifications of the palatine teeth as the only character on which a distinction can be based, and Garman himself (1911, p. 97) remarks on the danger of such a practice on account of the extent to which the teeth may change with age and use.

Barnard (1925, p. 96) maintained that Garman's recognition of *C. capensis* Duméril as distinct from *C. callorhynchus* was correct 'on the form of the dental plates'. He examined many specimens, but does not say how many or of what size, though from two maximal measurements given it is certain that he saw at least two large specimens.

Is the form of the tritors of the palatine lamellae a good specific character? They are essentially the same in the young of all these 'species', and no author has yet defined the stage at which the differentiation becomes apparent. Moreover, the fossil *C. hectori* Newton, 1876 is said by Garman to agree with *C. capensis* in respect of this character. This fossil was found in what are probably cretaceous rocks in New Zealand. One can recall teleosts in which teeth regarded (by some) as diagnostic in the adults are absent in the young and 'occasionally absent' in large specimens.

We may say of the species of *Callorhynchus* that *smythii* Bennett, 1839 is a synonym of *callorhynchus* (Linnaeus), 1758, while *milii* Bory, 1823 may prove to be another synonym. *C. capensis* Duméril, 1865 may be distinct, but the whole problem appears insoluble by purely verbal descriptive methods, and must wait upon the collection of long series of adequate biometric data.

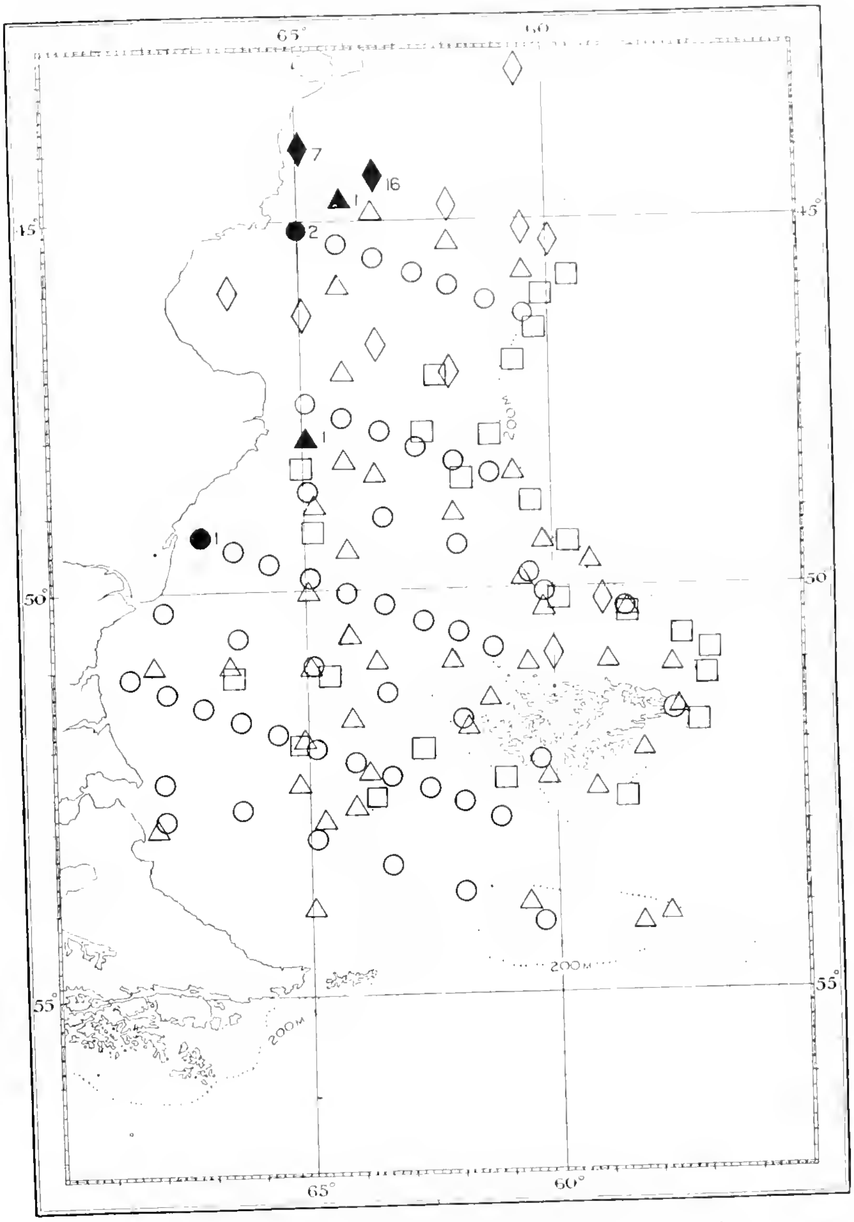

Fig. 17. Distribution of *Callorhynchus callorhynchus*. Spring: diamonds; summer: circles autumn: triangles; winter: squares; negative observations left blank.

It will be seen from the data recorded below that we were not able to preserve all the specimens secured, so that our records do not tally exactly with those given by Norman (1937, p. 36). Some mistake has occurred over the specimen recorded by Norman as a female of 80 cm. from St. *WS847*. The depth given by Norman is wrong for that station, where we secured and weighed a female of 90 cm.; a female of 81 cm. (when fresh) was taken at St. **WS853**, and this is probably the specimen referred to by Norman. Most of our preserved material showed some shrinkage, but a decrease of over 10% in length is unlikely. Gunther and Rayner, who examined all the specimens in the field, were in no doubt as to their specific identity, and fully agreed with Norman's view as to the synonymy of *C. smythii* and *C. callorhynchus*. The particulars for the specimens not seen by Norman are given separately:

WS96	1	**WS763**	16	*WS847B*	1
WS762B	7	**WS788**	2	**WS853**	1

Specimens not seen by Norman: **WS762B** 1 male of 48 cm.; **WS763** unsexed specimens of 25, 30, 31 and 33 cm. and one unmeasured; **WS788** unsexed specimens of 32 and 40 cm.; *WS847B* one female of 90+ cm. (tail damaged), weight 4750 g.

SUMMARY OF OBSERVATIONS ON ELASMOBRANCHII

The main features of the distributional trends of the various species of elasmobranchs found on the shelf are summarized in Tables 7 and 8. These show frequency of occurrence relative to the total number of hauls made in each region, and abundance of individuals in each region relative to the total for each species for all regions. With these and the data given in the Appendix any desired computation as to fish per hour's trawling, or per hour's positive hauls, could also be made; but as the group is not sufficiently abundant to encourage commercial exploitation, I have not done so here.

Table 7. *Distribution of Elasmobranchii: occurrence in total of roughly comparable hauls in each region*

Species	Northern region		Intermediate region		Southern region	
	No.	% of hauls +	No.	% of hauls +	No.	% of hauls +
Squalus lebruni	3	11·1	1	1·89	2	2·08
Raja flavirostris	8	29·63	9	16·98	7	7·29
R. doello-juradoi	2	7·41	4	7·55	6	6·25
R. macloviana	1	3·70	3	5·66	8	8·33
R. magellanica	1	3·70	7	13·21	13	13·54
R. scaphiops	1	3·70	0	0	4	4·17
R. albomaculata	0	0	0	0	6	6·25
R. brachyurops	6	22·22	17	32·08	26	27·08
R. griseocauda	1	3·70	1	1·89	4	4·17
Psammobatis scobina	4	14·81	17	32·08	24	25·00
Callorhynchus callorhynchus	4	14·81	1	1·89	1	1·04
Number of roughly comparable hauls	27		53		96	

Table 8. *Distribution of Elasmobranchii: regional abundance of individuals of the trawled species*

Species	Total no. of individuals	Northern region		Intermediate region		Southern region	
		No.	%	No.	%	No.	%
Squalus lebruni	8	3	37·5	1	12·5	4	50·0
Raja flavirostris	39	10	25·6	18	46·2	11	28·2
R. doello-juradoi	68	5	7·4	5	7·4	58	85·2
R. macloviana	23	4	17·4	7	30·4	12	52·2
R. magellanica	54	1	1·9	27	50·0	26	48·1
R. scaphiops	7	2	28·6	0	0	5	71·4
R. albomaculata	7	0	0	0	0	7	100·0
R. brachyurops	292*	43	14·7	53	18·2	196*	67·1
R. griseocauda	8	2	25·0	2	25·0	4	50·0
Psammobatis scobina	157†	5	3·2	93‡	59·2	59§	37·6
Callorhynchus callorhynchus	28	26	92·8	1	3·6	1	3·6
Total Elasmobranchii	697‖	77¶	11·0	211**	30·3	409††	58·7

* Includes eighteen southern specimens taken in 'Other gear'.

‡ Includes two taken in 'Other gear'.

‖ Includes six rare specimens not tabulated.

** Includes four *Discopyge tschudii* not tabulated.

† Includes three taken in 'Other gear'.

§ Includes one taken in 'Other gear'.

¶ Includes one *Psammobatis extenta* not tabulated.

†† Includes one *Raja multispinis* not tabulated.

Fig. 18, to which frequent reference has been made in the notes on individual species, summarizes the main features of their depth distribution. The statistical significance of the differences between the effective mean depths observed for the several species, which are plotted in the figure, are given in Table 9.

It will be seen that the species may be grouped into three classes according to their depth relations, thus:

I. Shallow, species of the shelf: *Squalus lebruni*, *Raja flavirostris*, *R. magellanica*, *Psammobatis scobina* and *Callorhynchus*.

II. Intermediate depths: *Raja macloviana* and *R. brachyurops*. The peculiar depth distribution of the last named has been shown to be due to a seasonal migration over the shelf edge. The less common *R. macloviana* shows a general depth relation of the same type (an hour-glass or dumbbell-shaped polygon), and there are other grounds for supposing that a similar migration in that species is possible.

III. Deep-water species found almost exclusively over the shelf edge: *R. doello-juradoi*, with the rarer forms *R. scaphiops*, *R. albomaculata* and *R. griseocauda*.

CLUPEIDAE

Clupea fuegensis (Jenyns). This is one of the most numerous and important species of our area, but owing to its mainly pelagic habits and small ('pilchard') size, it could not be adequately sampled with our gear. For this reason I give only the list of stations where it was captured. The numbers mean very little. The Falkland herring is a most important forage fish for larger species, especially hake, and is also extensively eaten by birds and seals. It is possible that it could be utilized directly for human food—it is most excellent eating, as the Falkland islanders well know—but prospects of regular captures in numbers sufficient to support, say, a small canning factory are not good. Any form of gill net would be continually threatened by seals and penguins anywhere within reasonable distance of the Falkland Islands, while the herring trawl would almost certainly fail on the rough bottom. Some specialized form of purse seining might possibly provide an answer.

Some other clupeoids recorded from the Patagonian region may be mentioned here, though we did not capture any of them, and they are probably not normal inhabitants of the area surveyed. The species known in Chile as 'sardina' was found by Norman (1937, p. 38) to be quite distinct from the typically eastern *C. fuegensis*. Norman has named it *C. bentincki*, after Mr Cavendish Bentinck, who sent him a fine series from Talcahuano harbour. From Col. Tenison's drawings it can at once be seen that it is much deeper in profile than the species so common on the continental shelf to the east. It resembles typical northern hemisphere herrings much more closely.

Gunther has a note that *Clupea* sp. (? *maderensis*) was on sale at the market in Buenos Aires, fetching 4 pesos per box of 126 approx. This species, he says, is represented farther south by *C. fuegensis*. It is therefore probably distinct from *C. melanostigma*, another clupeoid occurring in the River Plate estuary, which is stated by Norman (1937, p. 39) to be closely related to *C. arcuata*, a southern species much smaller than *C. fuegensis*, of 'sprat' as compared with 'pilchard' size.

We obtained specimens of *C. fuegensis* at the following stations, mostly in the 'accessory nets'.

WS86
WS89
WS90
WS214
WS220
WS222
WS223
WS224
WS234
WS242
WS762
WS781
WS783A
WS784
WS809A
WS809B
WS810
WS812I
WS812H
WS817A
WS817B
WS818
WS824
WS833
WS834
WS837
WS838
WS851
WS749 (N100B)
WS832 (NR)

Also: Stanley Harbour, 2. ii. 27 and Chartres River, West Falkland Islands, 13. iii. 32.

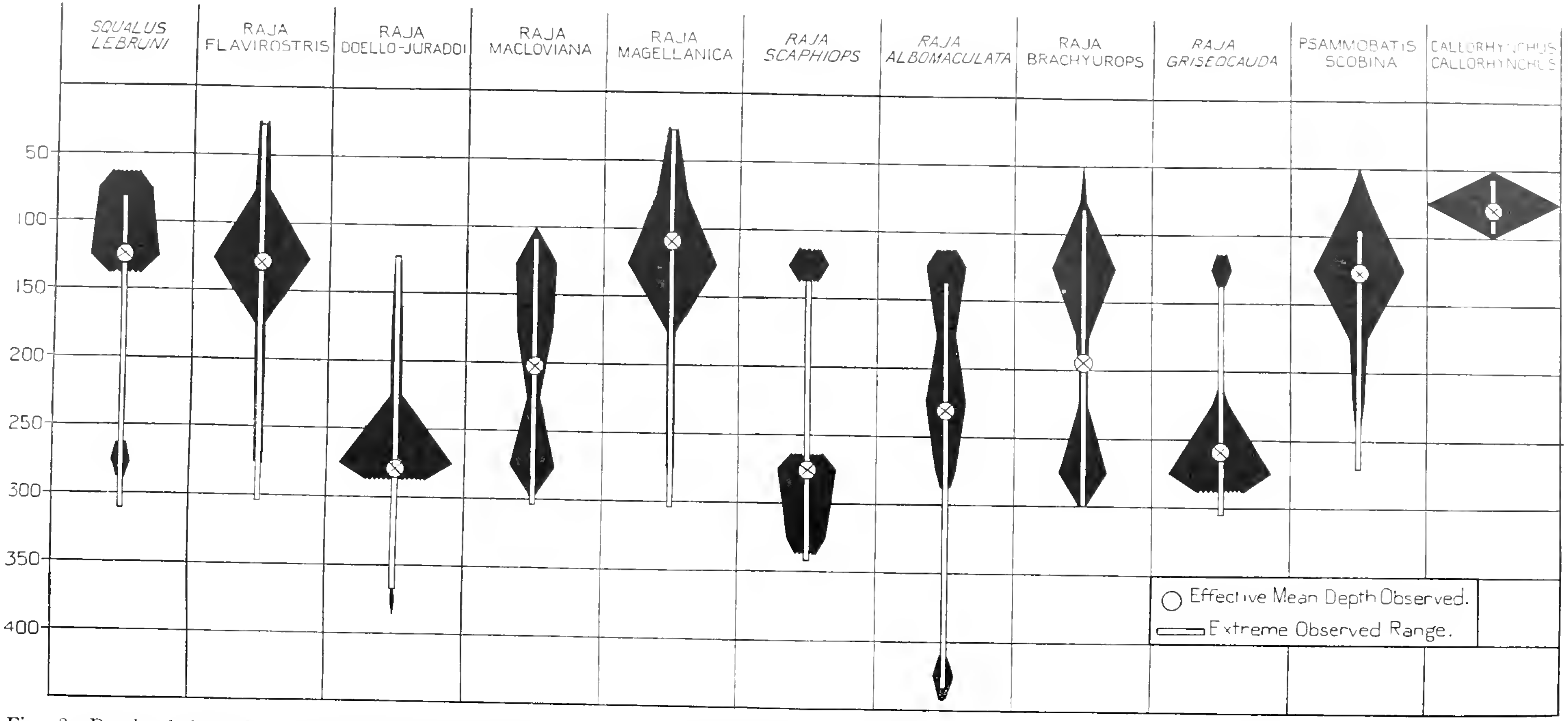

Fig. 18. Depth relations of the principal species of Elasmobranchii of the area surveyed. Species for which the data are less satisfactory owing to their rarity have their names given in *italics*. Depths in metres are shown in the scale on the left. The extreme observed range is taken from the least depth at the shallowest station to the greatest depth at the deepest station. Widths of black polygons are proportional to the depth frequency distribution when the observations are grouped in 50 m. classes.

Table 9. *Elasmobranchii: summary of differences in effective mean depth, and their significance*

Species	Total nos. in roughly comparable hauls, and effective mean depth	σ^2_M/N	Differences in effective mean depth observed (as plotted in Fig. 18) and their significance from the criterion $d/\sigma_d > 3$										
			Squalus lebruni	*Raja flavirostris*	*R. doello-juradoi*	*R. macloviana*	*R. magellanica*	*R. scaphiops*	*R. albomaculata*	*R. brachyurops*	*R. griseocauda*	*Psammobatis scobina*	*Callorhynchus callorhynchus*
Squalus lebruni	8 **127 m.**	435·8750	— —	*−2* *None*	*−152* *Sig.*	*−75* *Sig.*	+18 None	*−148* *Sig.*	*−104* *None*	*−67* *Sig.*	*−132* *Sig.*	+4 None	+47 None
Raja flavirostris	39 **129 m.**	68·5385	+2 None	— —	*−150* *Sig.*	*−73* *Sig.*	+20 None	*−146* *Sig.*	*−102* *None*	*−65* *Sig.*	*−130* *Sig.*	+6 None	+49 Sig.
R. doello-juradoi	68 **279 m.**	28·6843	+152 Sig.	+150 Sig.	— —	+77 Sig.	+170 Sig.	+4 None	+48 None	+85 Sig.	+20 None	+156 Sig.	+199 Sig.
R. macloviana	23 **202 m.**	161·7202	+75 Sig.	+73 Sig.	*−77* *Sig.*	— —	+93 Sig.	*−73* *None*	*−29* *None*	+8 None	*−57* *None*	+79 Sig.	+122 Sig.
R. magellanica	53 **109 m.**	33·0392	*−18* *None*	*−20* *None*	*−170* *Sig.*	*−93* *Sig.*	— —	*−166* *Sig.*	*−122* *Sig.*	*−85* *Sig.*	*−150* *Sig.*	*−14* *None*	+29 Sig.
R. scaphiops	7 **275 m.**	515·0408	+148 Sig.	+146 Sig.	*−4* *None*	+73 None	+166 Sig.	— —	+44 None	+81 Sig.	+16 None	+152 Sig.	+195 Sig.
R. albomaculata	7 **231 m.**	1231·7143	+104 None	+102 None	*−48* *None*	+29 None	+122 Sig.	*−44* *None*	— —	+37 None	*−28* *None*	+108 Sig.	+151 Sig.
R. brachyurops	274 **194 m.**	22·3525	+67 Sig.	+65 Sig.	*−85* *Sig.*	*−8* *None*	+85 Sig.	*−81* *Sig.*	*−37* *None*	— —	*−65* *Sig.*	+71 Sig.	+114 Sig.
R. griseocauda	8 **259 m.**	307·4375	+132 Sig.	+130 Sig.	*−20* *None*	+57 None	+150 Sig.	*−16* *None*	+28 None	+65 Sig.	— —	+136 Sig.	+179 Sig.
Psammobatis scobina	153 **123 m.**	5·4424	*−4* *None*	*−6* *None*	*−156* *Sig.*	*−79* *Sig.*	+14 None	*−152* *Sig.*	*−108* *Sig.*	*−71* *Sig.*	*−136* *Sig.*	— —	+43 Sig.
Callorhynchus callorhynchus	28 **80 m.**	4·8546	*−47* *None*	*−49* *Sig.*	*−199* *Sig.*	*−122* *Sig.*	*−29* *Sig.*	*−195* *Sig.*	*−151* *Sig.*	*−114* *Sig.*	*−179* *Sig.*	*−43* *Sig.*	— —

Clupea arcuata Jenyns. Our gear was even less suitable for sampling this small coastal but mainly pelagic species, which is very closely related to the European *C. sprattus*, and which is known to be abundant at times within the area surveyed. In life the muscles show up yellow through the skin, permitting rapid distinction from small fry of *C. fuegensis* of similar size. Doubtless a frequent food of larger fishes, we only happened on it in numbers at St. *WS89*, where thirty-nine were taken in the N 7-T attached to the back of the trawl. This station was worked in very shoal water close in to the north-east coast of Tierra del Fuego. Quite possibly the normal habitat of the species is too coastal for it to have been taken by the fine 'accessory nets' on other occasions.

GALAXIIDAE

Galaxias attenuatus (Jenyns). This fish was not trawled by us—it is improbable that they ever depart far enough from the coast to be sampled by a trawl—but a Falkland specimen was readily obtained for Norman's report of 1937 by Mr Bennett. The majority of the galaxiids are fresh-water species, though an increasing number have been found in the sea. Most of them can probably be regarded as anadromous. *G. attenuatus* is catadromous, descending to brackish water or to the sea itself to spawn. It is possible that much of the spawning takes place in the lower reaches of estuaries rather than in the sea itself (Phillips, 1924), but it is certain that the larvae must be widely distributed in the sea, or the species could never have populated the smaller brooks in which it is found, for many of these have no estuarine transition area at their mouths. Moreover, there is an interval between the time of known spawnings and the records of upstream movements of larvae. A species of *Galaxias* unknown in fresh waters, *G. bollansi* Hutton, was described in 1899. Very recently, Scott (1941) has shown that apart from *G. attenuatus* (which he studied in very great detail in an earlier paper there quoted) the type species of the genus, *G. truttaceous* Cuvier, is euryhaline, and that 'it is not improbably facultatively catadromous, and that when not confined in land-locked waters it may retain the presumably primitive spawning habit of the family'. Since Scott had already shown (1938, pp. 125–6) that young *G. truttaceous* may arrive with the upstream spring immigration of *G. attenuatus*, that adults descend (1941, pp. 57 et seq.) to almost completely saline sea water, and that when ripe they are found at or near the coast (p. 68), his conclusion seems most cautiously worded.

I cannot understand why the catadromous migration of *G. attenuatus* was ever doubted. Beginning with Hutton in 1872[1] the facts had been described by several observers in New Zealand, Tasmania and Australia, who were familiar with the fish in life. It is true that McCulloch (1915) had had to improvise a very primitive experiment in the endeavour to prove his point, but there is nothing to show that it was not effective; and Meek's assertion (1916, p. 147) that the $3\frac{1}{2}$–4 cm. larvae are denatant is at variance with McCulloch's direct observations. It is, indeed, probable that the catadromous migration of *G. attenuatus* was well known and understood by the Maori—who still eat them—before white men ever came to New Zealand. Phillipps (1919, quoting Best, 1903) was doubtful of one traditional Maori account that described spawning at the mouths of rivers. He then thought that the spawning was entirely marine, but within five years his own observations (Phillipps, 1924) had shown that the Maori account was substantially correct. It may seem unnecessary to labour the point now, but *G. attenuatus* is an important fish in New Zealand, where the ascending fry are captured and canned as 'whitebait', at one time the only fishery product exported from the Dominion. Moreover, visiting the Dominions twenty years afterwards in a research ship, one found that biologists 'from home' still tended to be weighed on their willingness to accept enlightenment on the subject.

The general distribution of *G. attenuatus* is of particular interest; it is known from southern Australia, Tasmania, New Zealand, both coasts of Patagonia and the Falkland Islands. The family

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[1] I have not seen this paper.

Galaxiidae has a marked 'circumpolar sub-Antarctic' distribution, but the other, mostly more truly lacustrine, species have localized distributions, and only *G. attenuatus*, known to be catadromous, extends across the great ocean barriers.

According to Phillipps and Hodgkinson (1922) the older lacustrine stages of *G. attenuatus* are generally known as 'minnows' in New Zealand. The young fry eaten as whitebait are very good. All the whitebait examined from Auckland market were found to belong to this species.[1] They were on sale in August, September and October.

In the Falkland Islands *G. attenuatus* is one of several fishes locally termed 'smelt'. They sometimes shoal in littoral waters, probably when spawning, or later when re-entering the rivers. Their excellence as food is already appreciated. Adults are said to attain a length of 6 in. which is consistent with Scott's voluminous biometric data from Tasmania. This is undoubtedly one of the most promising species for *small-scale* local exploitation. Owing to the small size of the rivers in the Falkland Islands the scale of operations would have to be kept down, or rapid depletion would result. The stock cannot be a large one, for there is not enough fresh water to maintain large quantities of the maturing adults.

Galaxias maculatus (Jenyns), which occurs in the Falkland Islands and on both coasts of Patagonia, was not obtained by us. It is known chiefly in streams and brooks, but also occurs in the sea (Norman, 1937, p. 40). In the Falklands it is known as 'trout', but this local name is also given to *Aplochiton zebra*. It is noteworthy that the larger galaxiids of southern Australia, Tasmania and New Zealand were also called 'trout' by the settlers until the artificial introduction of true salmonids from the northern hemisphere. There is frequent evidence of acute observation in the application of the 'nearest' common name to quite remotely related fishes in some instances; while in others, also dating from the great period of human expansion, no discretion at all has been used.

APLOCHITONIDAE

Aplochiton zebra Jenyns. No specimens of this fish were obtained by the expedition, but Bennett found a specimen which had been collected in 1912 and forwarded it to Norman when the latter's report was being written. Known locally as 'trout', it is liable to be confused with *Galaxias maculatus*, but there is no reason to suppose that it is so rare as its scarcity in collections might indicate. Indeed, it was probably one of the first fishes ever observed in the Falkland Islands, Norman (1937, p. 137) provisionally identifying it with the 'truite' of Bougainville (1771). It was not until Darwin brought specimens home from the voyage of H.M.S. 'Beagle' that it was accurately described and named by Jenyns in 1842.

SYNGNATHIDAE

Leptonotus blainvilleanus (Eydoux and Gervais). This pipefish was only recorded at one of the trawling stations, **WS762**, in the northern region, where four young specimens were taken. Norman (1937, p. 41) points out that this was the first record of the species from the east coast of Patagonia. On the west coast, where its presence had been known for half a century, the 'William Scoresby' also obtained a specimen in a tow-net, at St. WS 593.

MACRURIDAE

Coryphaenoides holotrachys (Günther). All our specimens of this, the largest macrurid of our area, were obtained in summer, in deep water, in the southern region. Most were found in the Falkland trough, the only part of the area where extensive trawling in considerable depths is possible. It may extend farther north, but there the steepness of the slope precludes adequate exploration at suitable

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[1] Tasmanian whitebait consist largely of Aplochitonidae with *G. attenuatus* and sometimes *G. truttaceus* (Scott, 1936).

depths. Out of ninety specimens, two only could have been taken in less than 150 fm., and none in less than 272 m. The only large catch showed a high proportion of males, but at WS821A (ten individuals) the entire catch consisted of females, which generally preponderated in the small catches:

WS818A	2 ♀♀	*WS820*	1 ♀
WS818B	2 ♀♀	*WS821A*	10 ♀♀
WS819A	3 ♀♀	*WS839*	69: 54 ♂♂, 15 ♀♀
WS819B	2 ♀♀	*WS840*	1 ♂

Coelorhynchus fasciatus (Günther). All our specimens of this species were obtained in summer and autumn (third survey) in deep water over the shelf edge, mainly in the Falkland trough. Out of 140 specimens captured one only could have been taken in less than 200 m. of water. A notable preponderance of females was observed in three out of four catches of fourteen or more individuals. This may be due to the higher escape ratio of the smaller males, but abnormal sex ratios were also observed in *Coryphaenoides*, and it may be that there is a tendency towards sexual segregation among shoals of fishes belonging to this family at certain seasons. It is possible that the geographical range of *Coelorhynchus fasciatus* extends considerably farther north. Owing to the steepness of the descent from the shelf there our chances of trawling in suitable depths were extremely limited. It is noteworthy that this smaller species, though found exclusively over the edge like members of the family everywhere, favoured slightly shallower depths than did *Coryphaenoides*.

From Phillipps (1921) we learn that *Coelorhynchus australis*, called 'javelin-fish' in New Zealand, is occasionally taken by trawlers in Golden Bay, and highly esteemed as a food fish. It may therefore be that the usual dumping of macrurids, as 'rattails' among the rubbish of trawl catches, as is general off the British Isles and off South Africa, is a needless waste. If *Coryphaenoides* is similarly edible it would be the more valuable of the two Patagonian species on account of its larger size—up to 87 cm. as against 38 cm. in our catches:

WS817A	1	*WS819A*	3 (2 ♂♂)	*WS829*	7 (all ♂♂)
WS817B	57 (4 ♂♂)	*WS819B*	5 (4 ♂♂)	*WS840*	1
WS818A	15 (2 ♂♂)	*WS820*	14 (11 ♂♂)	*WS870*	8
WS818B	8 (6 ♂♂)	*WS821A*	14 (1 ♂)	*WS875*	7

MERLUCCIIDAE

Merluccius hubbsi Marini

INTRODUCTION: ECONOMIC IMPORTANCE OF ALLIED SPECIES

Merluccius hubbsi Marini, the Patagonian hake, is the most important and one of the most numerous fishes of the region. In our trawling catches it ranked third in numbers to *Notothenia ramsayi* and *Macruronus magellanicus*, but the weight of *Merluccius* captured exceeded that of the other two species combined, and formed 47·3% of the weight of *all* the fishes caught at eighty-three stations worked during the third survey for which weight data are available.

All the true hakes are very closely related; there is, indeed, still room for doubt as to whether some are specifically distinct. Their distribution raises many problems of great general biological interest which I hope some day to discuss at length elsewhere. For our present purpose it is sufficient to note that the Patagonian species is known to range from the southern coast of Brazil (probably from about the point where the Brazil current begins to swing offshore) to the neighbourhood of the eastern entrance to Magellan Straits. From Norman's (1937, p. 46) diagnoses there appears to be no doubt that it is specifically distinct from *M. gayi* (Guichenot), the common species of the west coast of South America, with which it was for long confused. Indeed, *M. hubbsi* in its general bodily proportions resembles the silver hake or 'whiting' of New England and the north-west Atlantic, *M. bilinearis*

(Mitchell), more closely than it does any other member of the genus; but here again Norman's scale counts point to the specific distinction being justified. (Compare Col. Tenison's figures of *M. gayi* and *M. hubbsi* (Norman, 1937, p. 46), with the figures of *M. productus* and *M. bilinearis* by H. L. Todd in Goode's *Atlas*, 1884, pl. 65.)

All the true hakes are edible: *M. merluccius* of Europe and North Africa, *M. bilinearis* of the north-west Atlantic and *M. capensis* (Castelnau) of South Africa are already the staple of important fisheries. *M. productus* (Ayres) of the north-east Pacific has been little utilized, and the same may be said of *M. australis* (Hutton) of New Zealand; but so long ago as 1907 the British Columbia Fisheries Commission reported that *M. productus* was not inferior to the Atlantic species, and it would seem that their neglect is due merely to the plenitude of better food fishes in these favoured regions. *M. gayi* of Chile is captured and eaten locally, but its exploitation by modern large-scale trawling methods is rendered impossible by the absence of any continental shelf on the west coast of South America. Finally, the Patagonian species *M. hubbsi* is captured by the small trawling industry operating from the mouth of the River Plate. This originated with Don Pedro Galceran in Montevideo, but the Uruguayan enterprise failed and the small-scale industry was then carried out from Buenos Aires (Devincenzi, 1926). In 1932, when Gunther visited the fish market at Buenos Aires, he found that 'merluza' were selling at 0·50 pesos per kg. The Buenos Aires trawlers are not known to have operated anything like so far afield as the area we surveyed. Up to the time of our last survey (1932) it was said that they rarely proceeded out of sight of the land at the mouth of the Plate.

In order to assess the potential value of Patagonian hake we may briefly consider the history of the exploitation of the three species of *Merluccius* that already provide the raw material for considerable industries.

The European hake, *M. merluccius* (Linnaeus), ranges from the Norwegian Rinne southwards along the edge of the continental shelf as far as Dakar on the Mauritanian coast, and perhaps even farther south. A local race has been reported off Cape Verde (Belloc, 1937). Belloc's observations on vertebral numbers show that, while the previously known stocks of European hake from Mauritania northwards to the west of Ireland, had 'vertebral numbers' regularly increasing from 50·48 (±0·29) to 51·15 (±0·16), the number for the large sample he obtained off Cape Verde was 54·09 (±0·13) (loc. cit., fig. 3). This is of exceptional interest because increased numbers towards the *northern* end of the range of such diverse species as cod (Schmidt, 1930) and herring (numerous workers, quoted by Schmidt) have been observed, and seem possibly connected with the effects of lower temperatures upon the rate of development of the larvae in different localities. The North American cod stocks show higher vertebral numbers all round than do those of north-western Europe, but here again Harold Thompson (1943, pp. 63–9) has shown that the highest numbers tended to occur in the colder localities. If Belloc is right in maintaining that the Cape Verde hake are but a local race of the European species—and he is emphatic that all its other characters support this view, and that it is quite distinct from the South African species, for which full biometric data are lacking—then we have a remarkable divergence from the rule that has been found to hold good for cod and herring, and that tends, moreover, to be followed by the other stocks of European hake for which data are available. It would seem that further detailed observations on vertebral numbers of *Merluccius*, with the precautions and refinements that Ford (1938) has shown to be desirable, could not fail to be of exceptional interest.

The hake is common in the Mediterranean, especially on the northern shore, where it has been 'mentioned in the literature' from the time of Aristotle (Couch, 1864, vol. III, p. 103; Day, 1880–84, vol. I, p. 300). It is an interesting fact that Faber (1883), who shows it to have been one of the most important of second quality food fishes in the Adriatic at the time of which he was writing (it was the principal fish captured at Fiume in 1879–80, ibid. p. 167), also mentions that the superiority of hooked over net-caught hake was so marked that they could command an appreciably higher price.

In the north records of *M. merluccius* from Iceland have been confirmed, but some from south-west Greenland are more doubtful. Even at Iceland such stragglers are rare and represent the extreme range of the species. Hake are not common in the North Sea, though there is a regular small-scale immigration into the north-eastern portion of it. In fact the fish, which lives for a good part of the year over deep water off the edge of the continental shelf, is essentially an inhabitant of warm temperate waters from the west of Scotland southwards. Its southern limits in all probability are normally defined by the limits of influence of the Canary current, which is cold relative to the tropical surface waters south and west of it, and relatively rich in nutrient salts and all the larger forms of life (cf. Hentschel, 1936, p. 243 and Beilage ix).

M. merluccius, the merluce of heraldry, has been an important constituent of the fish food of the western European nations throughout historic times. In Britain it has been the subject of various commercial treaties from the time of King John to Queen Mary. Much was eaten during Lent. Latterly it fell into disfavour, partly perhaps because the disestablishment of the Church led to a less rigorous insistence upon traditional Lenten fare, but chiefly because improved boats and gear enabled fishermen to catch far greater quantities of the choicer fish than before. In France, Spain and Portugal it must always have been relatively important, owing to the lack of the colder-water gadoids near at hand; but as recently as the second half of the last century we find leading ichthyologists in this country dismissing it as a poor, coarse fish, of inferior table qualities. It is said, indeed, that the German and Dutch names for hake, Stockfische or Stokvische (there are others), derive from the habit of letting smack's boys keep them for 'stocker', which makes it certain that they were practically unsaleable.

The rapid development of otter trawling, especially the introduction of steam trawling, at the turn of the century saw a rapid decline in the *proportion* of prime fish landed (though of course the actual quantity was at first increased), and the development of fried-fish shops greatly stimulated hake trawling. Indeed, Hickling (1935*a*, pp. 70–1) has been able to show that there was serious depletion of the stock through overfishing before the war of 1914–18. During that war all fish stocks recovered to some extent, and with improved boats and gear (the V.D. trawl) and the development of deep-sea trawling on distant grounds throughout the whole latitudinal range of the species, British hake trawling showed increasingly heavy catches until well into the 1920's. But the catch was only maintained by increased fishing effort, as Hickling (1935*a*, pp. 74–5) has so clearly demonstrated. Since 1925 catches declined and depletion continued until 1939.

The importance of hake to the modern British trawling industry is very great. It is the staple catch of our great west coast trawling ports, Fleetwood, Milford, Cardiff and Swansea. Even in 1930, when decline of the stock was beginning to show itself, it ranked third of all our trawled fish whether reckoned by quantity or by value. Only cod and haddock were more important. During 1920–5 the British landings averaged 38,500 tons, and some of the fleet were working as far south as North Africa in winter. Throughout the inter-war period the intensity of fishing by French and (latterly) modern Spanish vessels, in the southern part of the range of the species, also greatly increased. Though the price of hake is influenced by many economic factors besides supply, the average value for the British catch at first sale for the period 1920–33 was £1,532,000 per annum (Hickling, 1935*a*, p. 74, fig. 7).

The silver hake ('whiting', of New England), *M. bilinearis* (Mitchill), ranges from Newfoundland to North Carolina. To the south it has been recorded (from deep water only) as far as the Bahamas and Florida (Longley and Hildebrand, 1941, p. 38).

The history of the commercial exploitation of *M. bilinearis* affords a close parallel to that of the

European hake, but with a characteristic acceleration due to the American fishermen having a totally undepleted stock to deal with when modern methods of capture and treatment of the catch were introduced. In dealing with this species it is important to realize that much of the earlier American and Canadian literature is vitiated by confusion between it and several species of *Urophysis* (Gadidae) which are called 'hake' with or without distinguishing prefixes along those coasts. The once important by-product trade in 'hake-sounds' for isinglass was based on these, and not on *Merluccius*.

In the early days silver hake were regarded as rubbish by the New England fishermen, and also as a great nuisance when large numbers were caught in mackerel nets (Goode *et al.*, 1884, pp. 240–3) and had to be discarded. Their inshore migration in summer appears to be even more marked than that of the European species, and they frequently become stranded in pursuit of prey. At times they were used for manure (Bigelow and Welsh, 1925, pp. 386–96), and as recently as 1895 only 37,000 lb. were marketed from Massachusetts and Maine. By 1919 more than 14 million lb. were sold, and even at that date most were still caught in traps and weirs, the price being too low for the offshore fishermen to bring in those they captured. Since then the demand has increased enormously with the development of large cold stores, especially in the mid-western states. From the *Statistical Digest* No. 4 of the U.S. Bureau of Fisheries (1940)—a mine of fascinating information—it can be seen that nearly 50 million lb. of *M. bilinearis* were marketed in that year, more than 80% of the total coming from the New England States. Nearly half this catch was frozen (forming 11% of the total frozen fishery produce of the country). It has, indeed, become the most important single species of the frozen fish trade. This rapid development has synchronized with a big change in fishing methods, more being taken in otter trawls than in pound-nets now, except in New Jersey and Rhode Island. One wonders whether the over-fishing problem may not soon become evident with the New England 'whiting'.

M. capensis (Castelnau), which is known in South Africa as stockfish or stokvisch, has been the staple of the modern trawling industry developed in that country. In the absence of adequate data there is still some room for doubt as to whether the distinction between this and the European hake is sufficient for *M. capensis* to be regarded as a separate species (Barnard, 1925, p. 320). The South African form ranges from Angola to Natal, in deeper waters towards the equatorial limits of its range on either side of the continent. It may be noted that this seems to be a general rule for all species of *Merluccius*, and for very many other fish besides. There are no statistics of the earlier commercial landings to enable one to trace the growth of the modern fishery at the Cape, but the figures for 1929–32 published by von Bonde (1934) leave one in no doubt as to the importance of *Merluccius*. In that period the catch was more than one-third of the total weight of fish landed: some 7850 tons of stockfish worth over £150,000 per annum.

Some figures relating to the size and value of the fisheries for these three species of *Merluccius* are summarized in Table 10 below. They reveal truly astonishing differences in the value of the fish in the countries concerned. The British catch used to be nearly double that of the American 'whiting' fishery, but its value at first sale was nearly eight times as great, weight for weight. The South African catch was about 40% of the weight of the American catch, with the value at first sale intermediate between the prices obtained in the other two countries: about 3½ times the value of the American and less than half the value of hake landed in Britain. While the difference between British and South African prices may in part be explained by the employment of cheap coloured labour in South Africa, the very much cheaper American prices point to profound differences in economic conditions which cannot be understood without first-hand knowledge of the 'whiting' trade.

It would seem, therefore, that while it is obviously desirable to examine our biological data concerning Patagonian hake in the light of the knowledge accumulated concerning the species already exploited (as Mr John pointed out long ago), it will not be possible to assess the commercial prospects by direct biological comparison alone. Peculiar economic and even political considerations—in fact, the bionomics of the prospective human producers and consumers—play at least an equal part in the determination of industrial possibilities. At the same time, some knowledge of the natural history of the Patagonian species is obviously a basic necessity in any attempt to deal with the problem. Our data are therefore considered here from the biological point of view, while suggestions as to commercial prospects are deferred to a later section of this report where the summarized weight data allow one to take into account the possible value of other less important species.

Table 10. *Figures illustrating the size and relative values of the principal fisheries for* Merluccius *spp.*

Country, period, species, source of information	Approximate average annual catch in tons, cwt. or lb.	Average price at first sale per unit of weight, in sterling or in $
Great Britain 1920–33 *Merluccius merluccius* Hickling (1935)	36,904 tons or 738,088 cwt. or 82,666,000 lb.	£41. 6*s*. 1¾*d*. or $171.49; £2. 1*s*. 6*d*. or $8.62; 4½*d*. or nearly 8 c.
United States 1939 and 1940 *Merluccius bilinearis* *Statistical Digests*, 1 and 4	19,767 tons or 395,335 cwt. or 44,277,500 lb.	£4. 19*s*. 2¾*d*. or $20.62; 4*s*. 11½*d*. or $1.03; ½*d*. or just under 1c.
Union of South Africa 1929–32 *Merluccius capensis* von Bonde (1934)	7845 tons or 156,900 cwt. or 17,572,800 lb.	£19. 9*s*. 3*d*. or $79.15; 19*s*. 0½*d*. or $3.95; 2*d*. or 3½c.

THE SIZES OF PATAGONIAN AND EUROPEAN HAKE COMPARED

First, it is desirable to establish the sizes of the hake we captured and to see how they compare with the sizes of better-known species captured with similar gear.

If it were possible to obtain 'ideal samples' of a slow-growing fish like hake, whose length increases almost as a linear function of age, the length frequencies, when plotted graphically, would approximate to the *lx* curve of a life table (a curve like a left-handed ogive, but with the curvature reversed and enormously produced at the very beginning, because of the high infant mortality rate). An imaginary curve of this nature is shown by the solid line in Fig. 19. It would begin with astronomical numbers of newly-hatched larvae, and end with the largest hake caught. Departures from this curve would, in part, be due to slight changes in growth rate. Such fish grow rather faster than usual early in life and slower near the end of their lives. The straight line of the age-length relationship becomes slightly bent at the ends, approaching a parabola.

But the ideal length-frequency distribution would show other more important deviations about the smoothed curve if considered with small class intervals (say 1·0 cm.): there would be modes or shoulders whose magnitude would reflect the differential survival of hake hatched in successive years, the resultant of all the environmental factors, animate and inanimate, that influenced their lives. An imaginary distribution of this type is shown by the pecked line in Fig. 19. Hake have a prolonged spawning season, and the changing environmental conditions would not have favoured early- and late-hatched fry equally in successive years. This would be a further source of variation in the modes or shoulders in our imaginary curve, for it is their dispersion that helps in age determination, and this, even more than their magnitude, may thus be distorted. In actual hake samples this factor so complicates the length-frequency distribution that Pettersen's method of age determination is rendered unsatisfactory except for the younger (smaller) fish.

In practice samples of a hake population are modified by the catching power of the trawl used. An 'idealized' trawl, that captured *all* of the fish above a certain size in its path and allowed *all* the others to escape, can be imagined to catch samples showing a length-frequency curve of the same pattern as our 'ideal' sample, but with the point of origin at (say) 40·0 cm. instead of the length of the newly-hatched larvae. Unfortunately such ideal conditions do not exist, and the selective action of a sampling instrument such as a commercial otter trawl of normal mesh retains a varying proportion of the smaller fish below the size at which all are captured. The proportions of these smaller fish retained varies in regular fashion according to their size, and follows yet another ogive curve, the 'selection ogive' of the trawl used. Selection ogives for trawls of different mesh taking European hake are given by Hickling (1933, p. 71, fig. 38). It will be seen that as the size of the mesh is increased and the selection ogives become centred higher in the length scale the curves slope less steeply. Theoretically it would be possible to obtain length-frequency samples approximating to a normal distribution by increasing the size of the mesh.

By covering an ordinary trawl with shrimp netting, Hickling has been able to obtain samples which, when treated cumulatively over five annual surveys of the grounds to the south and west of Ireland, show length frequencies approximating to the smoothed curve one would expect in 'ideal' samples for hake upwards of two years old. No practical gear could sample the younger length classes simultaneously, for the minute fry are pelagic, and the yearlings do not inhabit the same grounds as the older fish. Curves of percentage length frequency of European hake, derived from Hickling (1933, table IXa), are shown in Fig. 20, where they may be compared with the age distribution (a partial 'life curve') upon which that particular series of mean lengths was based. These data of Hickling's also give us a valuable demonstration that the numbers of the two sexes of European hake are nearly equal, the actual ratio from that set of figures showing a slight preponderance of males. If samples such as can be obtained with a commercial trawl are considered, it is found that females preponderate to a considerable extent, owing to the higher escape ratio of the smaller males.

Unfortunately, such data as we have for Patagonian hake are not directly comparable with those for the European hake set out in Hickling's table IXa, but they do compare very well with mean values of the figures set out in his series of measurements on commercial trawlers, of European hake from areas 1–5 (Hickling, 1933, tables XIa, XIb). These areas cover that part of the European hake's geographical range most nearly comparable to the areas best sampled by the 'William Scoresby' when

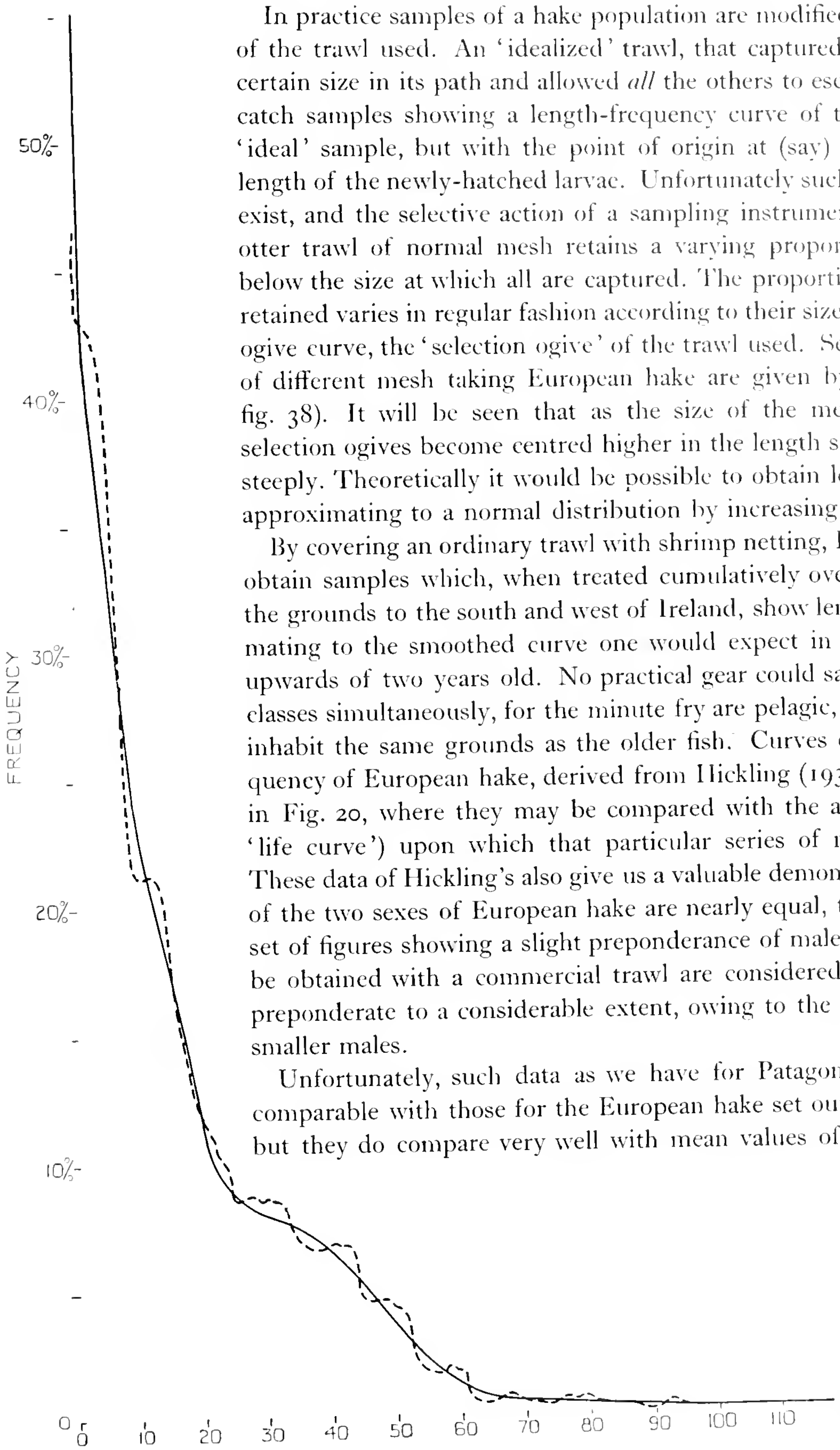

Fig. 19. Imaginary length frequency curves for an 'ideal sample' of hake. Solid line: smoothed curve; pecked line: with small class intervals.

catching hake off Patagonia, and direct comparison of the two sets of length frequencies seems highly instructive.

These data of Hickling's are given in the form of percentage length frequencies for each month, irrespective of sex, over a period of more than two years. To facilitate direct comparison with our southern data the results have been recalculated to exclude the very small number of fish less than 20·0 cm. long, and then meaned. For the southern species we have 4704 measurements of hake caught with a commercial trawl at all seasons, between 42 and 53° S, the latter probably being the normal southern limit of the species. In addition to the calculation of the mean, standard deviation, etc., by the long method, they have been secondarily grouped into 5·0 cm. length classes, and the percentage length frequencies computed, so that curves could be drawn for direct comparison with Hickling's data.

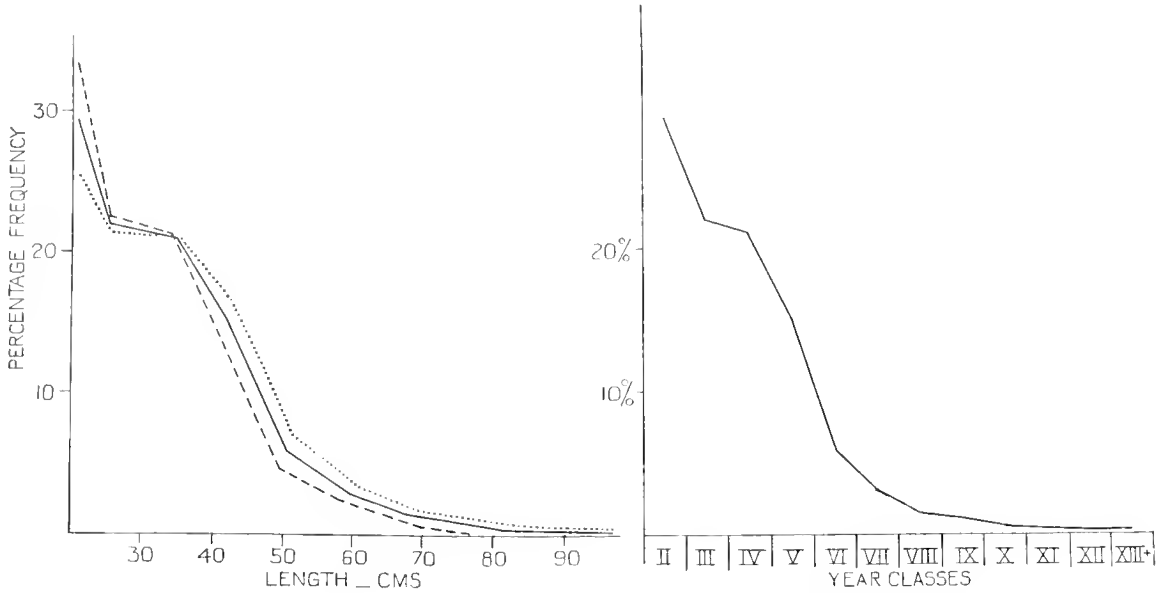

Fig. 20. Percentage length frequencies, and a partial life curve, for *Merluccius merluccius*. From Hickling, 1933, table IXa.

Before this comparison is made, it is necessary to make clear one most important difference between the two stocks: the males of the Patagonian hake are relatively much smaller than those of the European hake. It will be shown that Patagonian hake are some 5·0 cm. smaller than European hake, on the average, when the sexes are lumped together; but although directly comparable data for the separate sexes are not available, it can be shown that males of the Patagonian stock are relatively much smaller than this difference would indicate. Means for each sex of European hake may be obtained from Hickling's table IXa. While the means for the Patagonian stock are not directly comparable with these, the difference between the mean lengths for each sex, in each set of data, may readily be computed; and the difference *between these differences* is probably significant, though this cannot be established statistically. For Patagonian hake the difference is 49·9 cm. for females less 36·4 cm. for males, i.e. 13·5 cm. For European hake, with data including a much higher proportion of the smaller individuals of both sexes, it was 34·9 cm. for females less 31·0 cm. for males, i.e. 3·9 cm. Moreover, if we take the largest decile of the 1396 Patagonian males, we find that they show a mean length of 46·1 cm., the largest *individual* was 64 cm. long, and only 1% of the total of 50·0 cm. and over. The largest decile of the European males has a mean length of 56·1 cm., while the largest individual *age group* had a mean length of 76·7 cm.; and some 7% of the total were 50·0 cm. long and over, in spite of the much greater proportion of small individuals in this series of measurements.

From these considerations it would seem that if we assume the disparity in size between the sexes to be at least twice as great in Patagonian hake as it is in European hake, we shall not be far wrong.

Turning back to direct comparison of the lengths of the two stocks irrespective of sex, the figures for European hake being derived from Hickling's (1933) tables XIa and XIb as previously stated, we obtain the curves of percentage length frequency shown in Fig. 21*a*. This shows higher frequency of the European species in the higher length classes; but since all frequencies in these higher length classes are low, this difference is much better illustrated if the results are plotted on an arithlog scale, as in Fig. 21*b*. It must also be remembered that Hickling has shown that the figures for the European species were derived from a heavily overfished stock, in which the proportion of large fish had been seriously depleted, so that the smaller size of the virgin Patagonian stock is even more marked than can be shown from these figures.

Proceeding to direct comparison of mean lengths it was found that the secondary grouping of the southern data leads to an error of $+0{\cdot}5$ cm. Further, the secondary grouping in itself reduces the significance of the difference between the means, for using percentage length frequency as the basis, N becomes 100, and the value of σ_d is grossly exaggerated. It is not surprising, therefore, that on comparing the means of the two sets of percentage length frequencies and applying the test $d/\sigma_d > 3$, their difference cannot be shown to be significant. Thus:

European: $M_1 = 51{\cdot}4, \quad \sigma_1 = 15{\cdot}475, \quad \sigma_1^2 = 239{\cdot}476, \quad N_1 = 100;$

Patagonian: $M_2 = 46{\cdot}4, \quad \sigma_2 = 12{\cdot}535, \quad \sigma_2^2 = 157{\cdot}126, \quad N_2 = 100;$

$$d = M_1 - M_2 = 51{\cdot}4 - 46{\cdot}4 = 5{\cdot}0,$$

$$\sigma_d = \sqrt{\left(\frac{\sigma_1^2}{N_1} + \frac{\sigma_2^2}{N_2}\right)} = \sqrt{\left(\frac{239{\cdot}476}{100} + \frac{157{\cdot}126}{100}\right)} = \sqrt{3{\cdot}966} = 1{\cdot}99,$$

$$\frac{d}{\sigma_d} = \frac{5{\cdot}0}{1{\cdot}99} = \mathbf{2{\cdot}50}.$$

If, however, we take the *true* values for the southern species, calculated by the long method from all the individual observations, we have:

European (*M. merluccius*) values as before;

Patagonian (*M. hubbsi*): $M_2 = 45{\cdot}9, \quad \sigma_2 = 12{\cdot}42, \quad \sigma_2^2 = 154{\cdot}33, \quad N_2 = 4704;$

$$d = M_1 - M_2 = 51{\cdot}4 - 45{\cdot}9 = 5{\cdot}5,$$

$$\sigma_d = \sqrt{\left(\frac{\sigma_1^2}{N_1} + \frac{\sigma_2^2}{N_2}\right)} = \sqrt{\left(\frac{239{\cdot}476}{100} + \frac{154{\cdot}33}{4704}\right)} = \sqrt{2{\cdot}42757} = 1{\cdot}56,$$

$$\frac{d}{\sigma_d} = \frac{5{\cdot}5}{1{\cdot}56} = \mathbf{3{\cdot}53}.$$

Here the difference is clearly significant. Moreover, if the number of individual observations upon which our mean of Hickling's means depends were known, N_1 would be much larger, and the significance of the difference even more marked as σ_d diminished.

Even if we assume that the unknown grouping error introduced by calculating the mean length of the European species from the secondarily grouped percentage frequencies was of the same magnitude, and of *opposite sign*, from that which was found for the Patagonian data so treated, we should have $M_1 = 50{\cdot}9$, Patagonian values as before, $d = 5{\cdot}0$ and $\sigma_d = 1{\cdot}63$,

$$\frac{d}{\sigma_d} = \frac{5{\cdot}0}{1{\cdot}63} = \mathbf{3{\cdot}07}.$$

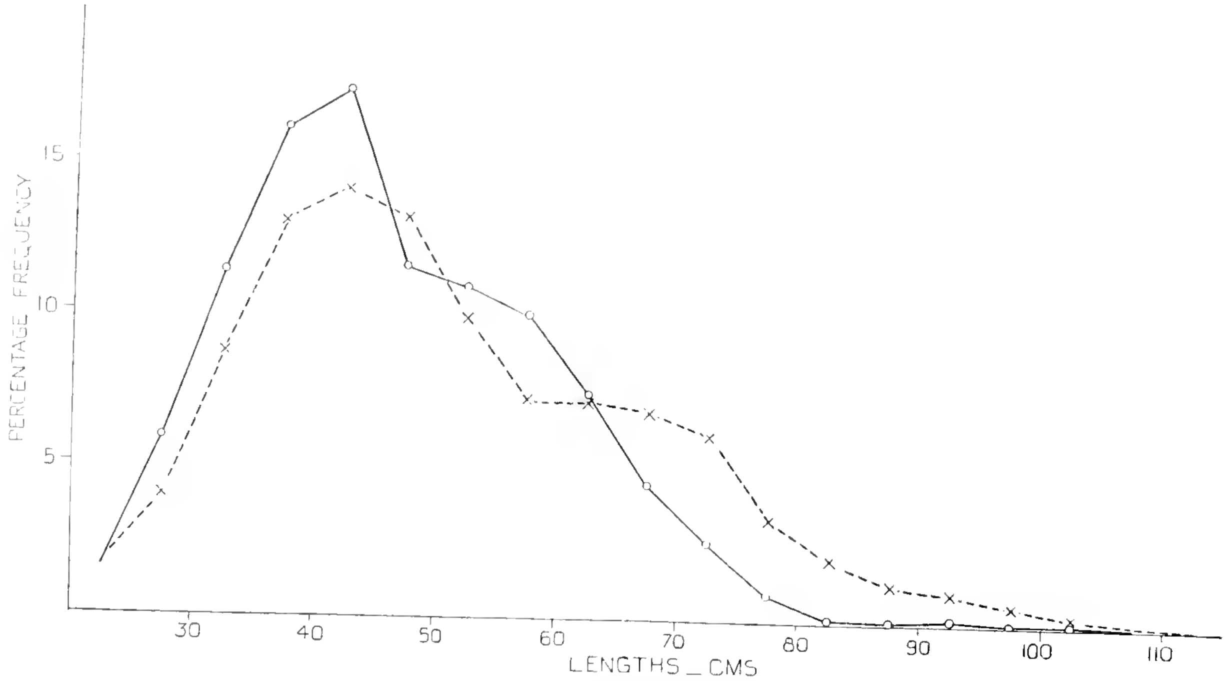

Fig. 21 *a*. Percentage length frequencies of *Merluccius hubbsi* and *M. merluccius*. *M. hubbsi*: continuous line; *M. merluccius*: pecked line. Data for *M. hubbsi* in Appendix II. Data for *M. merluccius* from Hickling, 1933, tables XI a, XI b.

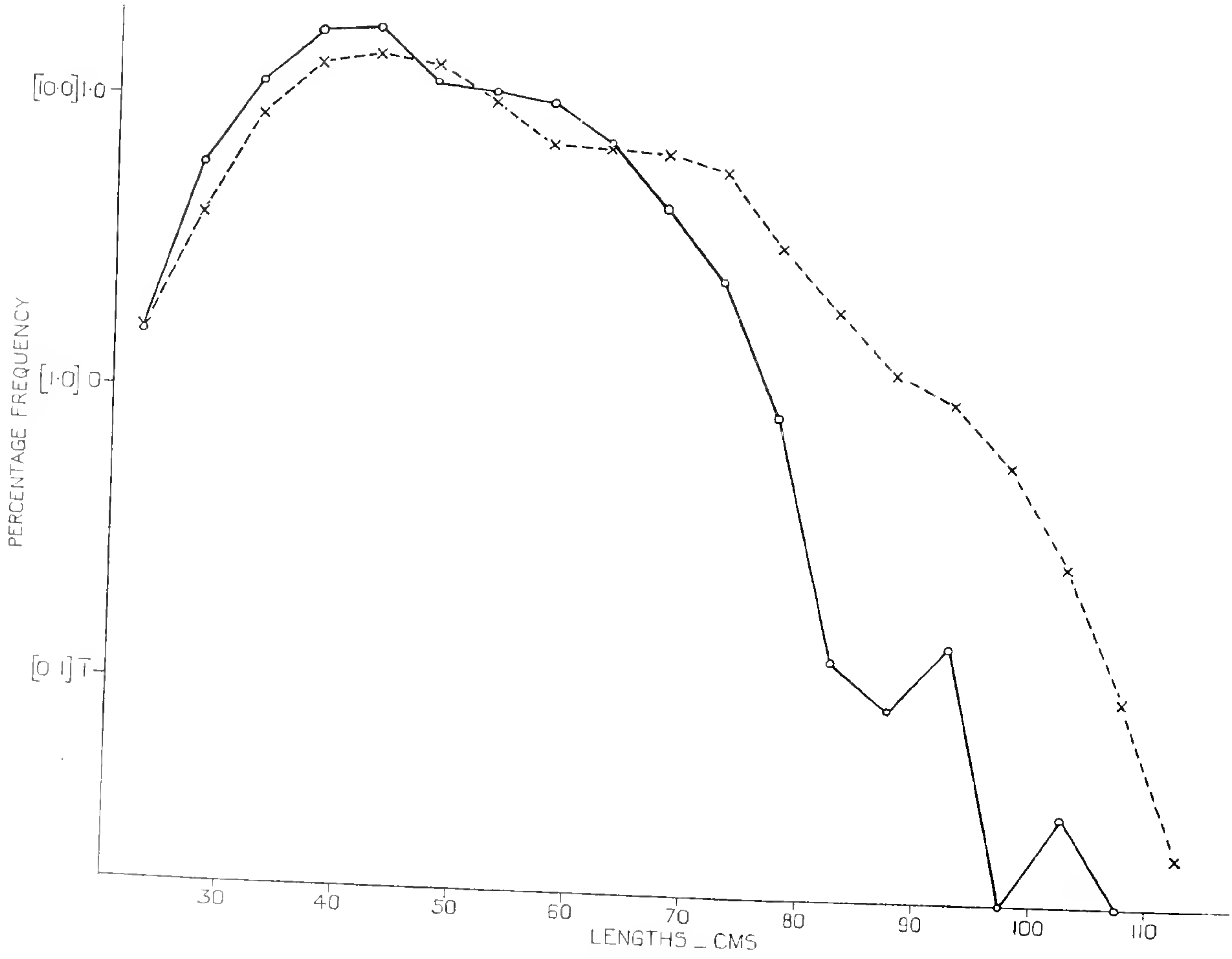

Fig. 21 *b*. The same as Fig. 21 *a*, on an arithlog scale.

It therefore seems quite clear that Patagonian hake really are some 5·0 cm. shorter than European hake, and that the disparity would be even more marked if it were possible to compare the males separately.

Another interesting point is brought out by comparison of the length-frequency curves: Patagonian hake, despite their smaller 'average' size, are relatively more numerous in the 50–60 cm. length classes (to the right of the mode) than are European hake. The sharp inflexion above the mode is doubtless due to scarcity of males over that length; but it can be seen that the succeeding flattened portion of the curve is on a distinctly higher level than the corresponding part of the curve for European hake of about 5 cm. greater length. The 50–60 cm. *hubbsi*—about 'ordinary chat' size by Fleetwood market standards of the period—probably correspond physiologically, if not in actual age, to European hake one category larger; so that it seems to me that we have here a striking indirect confirmation of Hickling's proof that the European stock was heavily overfished.

THE DISTRIBUTION AND RELATIVE ABUNDANCE OF *MERLUCCIUS HUBBSI* WITHIN THE AREA SURVEYED, AND THE EFFECT OF LATITUDE ON NUMBERS, SIZE AND SEX RATIO

The general distribution and abundance of this species cannot satisfactorily be shown on charts of such scale as could be reproduced here, because of its widespread occurrence and pronounced migratory movements. These are essentially similar to the migrations of the European and north-west Atlantic species, as will be shown in a later section. The occurrences of the species at our trawling stations have been tabulated *in extenso* in Appendices II A, B and C. From these it can be seen that the most important feature of the general distribution is a marked decrease in relative abundance from north to south. Local concentrations were encountered inshore in autumn (St. WS853, WS855), offshore in winter (St. WS216, WS217), and at intermediate distances from the coast in early summer (St. WS790, WS791). There were, of course, numerous less pronounced concentrations, most of which tended to conform to the general pattern of migration suggested by the extreme examples quoted.

Now since hake tend to be more closely congregated when on their inshore spawning migration, and the larger fish tend to move inshore first (cf. Hickling, 1927, p. 59, on the European species), a series of observations in early summer might give an erroneous impression of the effect of latitude on the size of the fish. Spawning takes place earlier in the year in the more equatorial part of the range of the species, and so considerable concentrations of individuals larger than the average for their latitude may be sampled when fish in higher latitudes are not so concentrated. At the same time, moderate numbers of the smaller hake, which do not seem to migrate so far or so fast, can nearly always be found in *relatively* shallow water throughout the year. In *Merluccius hubbsi* we found that the resultant of these factors completely masked the effect of latitude upon size of fish in December, but this effect was quite clear when the data for all seasons were considered together. A small series of observations in a single longitude taken over a narrow time interval later in the year, when the smaller individuals were at the peak of their inshore movement, also showed the effect of latitude quite clearly.

The general decrease in abundance of hake from north to south of our area is demonstrated by the figures in Table 11, which are taken from eighty-three hauls spread over the whole of the third survey. Earlier results are in agreement with these, but are not considered here because comparable weight data are lacking:

Table 11. *Decrease in relative abundance of* Merluccius hubbsi *with increasing latitude*

	Northern region 42–46° S	Intermediate region 46–50° S	Southern region 50–54° S
Number of hauls	14	29	40
Hours trawling	23	44	60
Mean number of hake per hour's trawling	100·48*	20·59	6·67
Mean weight of hake per hour's trawling	54·817 kg.	19·399 kg.	7·464 kg.

* Obviously fractional hake could not long exist in nature, and it is mathematically indefensible to treat fish as indiscrete objects but I feel that the fractional expression is less misleading than giving results as hake per 100 hr. trawling in order to get whole numbers, because these results are based on less than 100 hr. of comparable hauls in each region.

It will be seen that these figures provide evidence of the second feature of the influence of latitude already mentioned, namely, the increase in size (and weight) of the individual fish as one proceeds southwards. This can better be demonstrated by considering the mean lengths and length frequencies of the fish caught in the three regions, including data from the earlier surveys (Table 12).

Table 12. *Variation in size of* Merluccius hubbsi, *as shown by the differences in mean lengths for all comparable hauls in the three regions here surveyed, regardless of season. The sexes considered separately*

Note. The numbers of individuals do *not* indicate the relative abundance in the respective regions because of the very different number of hauls made in each of them. They show merely the number of individual measurements upon which these mean lengths are based. The sex ratios shown at the head of the table are based on a different array of the data, including some specimens sexed but not measured.

	Northern region	Intermediate region	Southern region
Sex ratio, % males	54·1	24·0	19·3
Males:			
No. measured	901	475	77
Mean length	35·9 cm.	37·7 cm.	38·9 cm.
σMl	5·5740	6·1837	5·4056
σ^2_{Ml}/N	0·0345	0·0805	0·3795
Difference in $Ml\ (=d)$	1·8 cm.		1·2 cm.
σ_d	0·3391		0·6783
$\therefore d/\sigma_d =$	5·3		1·77
Significance	Strong		Not significant
Females:			
No. measured	1260	1616	535
Mean length	47·3 cm.	50·2 cm.	55·5 cm.
σMl	12·5634	11·2877	12·0040
σ^2_{Ml}/N	0·1253	0·0788	0·2693
Difference in $Ml\ (=d)$	2·9 cm.		5·3 cm.
σ_d	0·4518		0·5900
$\therefore d/\sigma_d =$	6·4188		8·983
Significance	Strong		Strong

Table 12 shows the mean lengths of males and females of *M. hubbsi*, based on all the comparable data, for the three latitudinal regions, the differences in mean lengths between adjacent regions and their statistical significance. It can be seen that there is a clear increase in mean length with increase in latitude in both sexes, and that this is strongly significant except as between the males of the intermediate and southern regions. It can also be seen from the sex ratios given at the head of the table that males become increasingly scarce towards the south, and it is probable that this exception is due merely to insufficient sampling of the more southerly males caused by this scarcity.

Table 13. *Observed differences in populations of* Merluccius hubbsi *sampled in different latitudes between* 21 *March and* 30 *March*, 1932, *in long.* 64° 15′ *W*

	Northern region		Intermediate region		Southern region
Stations considered	WS853 and WS855		WS857, WS862 and WS864		WS866 and WS868
Mean latitude	45° 39′ S		48° 21½′ S		51° 10½′ S
Hake per hr. trawling	702		37		27
Sex ratios, % males	76·4		37·8		16·7
Males:					
No. measured	544		42		9
Mean length	35·2 cm.		39·3 cm.		42·4 cm.
σMl	5·1676		5·6454		1·5720
σ^2_{Ml}/N	0·0491		0·7588		0·2746
Difference in $Ml\ (=d)$		4·1 cm.		3·1 cm.	
σ_d		0·8988		1·0166	
$\therefore d/\sigma_d =$		4·56		3·049	
Significance		Clear		Just significant	
Females:					
No. measured	332		69		45
Mean length	39·9 cm.		48·3 cm.		56·0 cm.
σMl	10·3011		11·0042		9·1894
σ^2_{Ml}/N	0·3196		1·7550		1·8765
Difference in $Ml\ (=d)$		8·4 cm.		7·7 cm.	
σ_d		1·4404		1·9057	
$\therefore d/\sigma_d =$		5·832		4·041	
Significance		Strong		Clear	

Table 13 shows a similar consideration of more limited data from each of the three regions in the last ten days of March 1932 in one longitude. This array of the data also permitted comparable figures for relative abundance (hake per hour's trawling) and sex ratios to be given at the head of the table. Both show marked diminution towards the south. This falling off in the proportion of males is the third important feature associated with increasing latitude in populations of *M. hubbsi*. It would seem to imply that spawning activity must be much reduced near the southern limits of the range of the species.

Further demonstration of the effect of latitude upon size is given by Fig. 22. Here the length frequencies for either sex, in each of the three regions, have been summed into 5 cm. groups, reduced to percentages, and the results plotted graphically. The curves show quite clearly how small fish become more rare, and larger fish commoner, as one proceeds southwards. Incidentally, the figure provides a good illustration of the unusually large discrepancy in size between the sexes of *M. hubbsi* that has already been mentioned. Females are significantly larger than males among a large majority of fishes, but it is unusual to find differences as great as these.

THE RELATION BETWEEN LENGTH AND WEIGHT OF *MERLUCCIUS HUBBSI*, AND ITS VALUE AS AN INDICATOR OF THE SPAWNING SEASON, AND FOR OTHER PURPOSES

During our third survey the weights of male and female *M. hubbsi* were recorded in the form of bulk weighings of 10 cm. length groups, spring balances being used. Hickling (1930*b*, pp. 7, 8) has proved that these yield remarkably accurate figures at sea, even when used for much more delicate weighings than any attempted by us. The lengths of our fishes were known individually, so that a 'true' mean

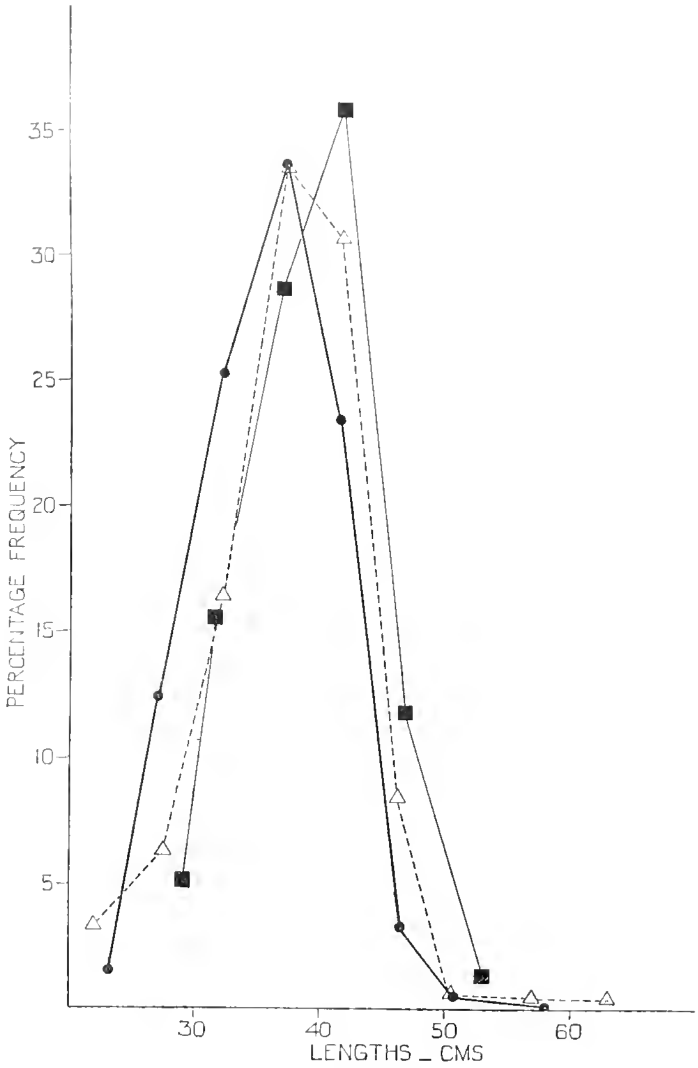

Fig. 22*a*. Percentage length-frequency distribution of male *Merluccius hubbsi* in different regions, plotted as 5 cm. groups. Thick line: northern region; pecked line: intermediate region; thin line: southern region. *Note.* The fish increase in size from north to south.

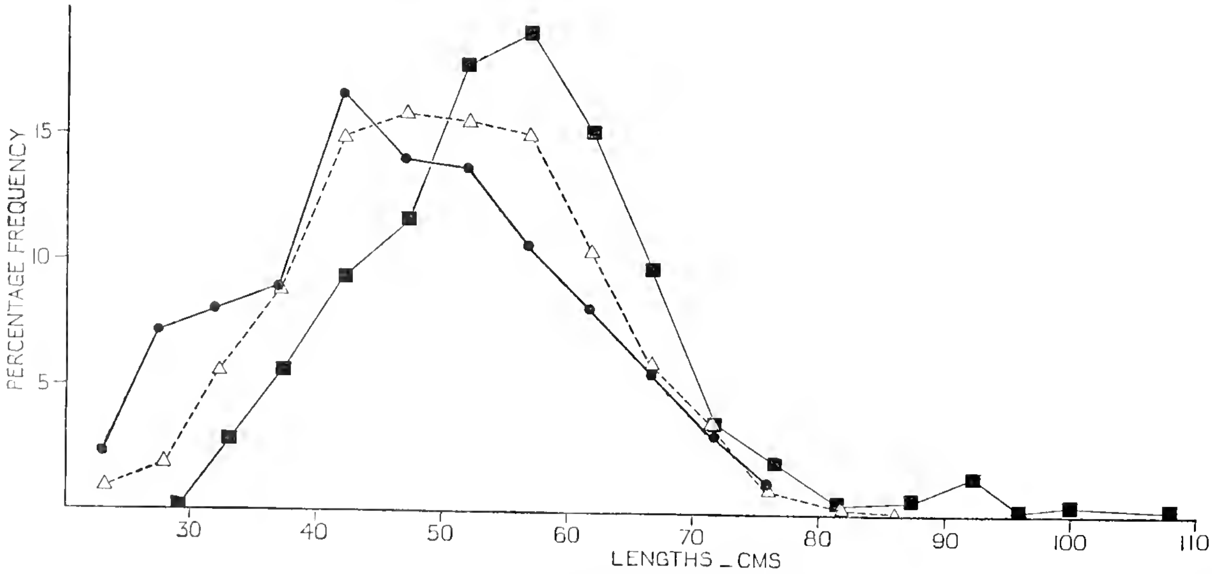

Fig. 22*b*. Percentage length-frequency distribution of female *Merluccius hubbsi* in different regions, plotted as 5 cm. groups. Thick line: northern region; pecked line: intermediate region; thin line: southern region. *Note.* The fish increase in size from north to south.

These graphs also serve to show the great disparity in size between the sexes of trawl-caught *M. hubbsi*.

length could be used to compute the ponderal index or condition factor K from each weight recorded. All the reliable data of this nature are given in Appendix II c. From them it has been found possible to trace the seasonal variation in K by using mean values from appropriate groupings of the results.

Throughout this work the 'ponderal index', 'condition factor' or 'weight-length coefficient' K has been calculated from the formula

$$K=\frac{w}{l^3}\cdot 100,$$

where w = mean weight in grams and l = mean length in cm.

The results suggest important analogies with those Hickling (1930*b*) obtained for the European species, but there are divergences, some due to the different methods employed, others probably to inherent differences between the two species. Here again it must be emphasized that Hickling, dealing with a single species, was able to concentrate his efforts, and weighed individual gutted fish and organs. Gunther and Rayner, on the other hand, were investigating virgin ground, so that it was necessary for them to 'do something about' everything that came up in the trawl, including 'rubbish'. The marvel is that they found time to make as many bulk weighings as they did, in addition to the vast number of individual measurements.

K values derived from heavily grouped data like these may still give us a good idea of the broad outline of the seasonal cycle for the species, although they cannot be expected to prove so accurate as more detailed results, especially if one were to attempt to apply them to individual fishes. They are mean K values, derived from *mean* weights and *mean* lengths. Applied to whole samples of fishes they permit of surprisingly accurate estimates of weight from known mean length (and the converse) as will be shown later, and these may be of great practical value. If, however, they are applied to the study of variations in condition of limited subsamples, they show features in contradiction to what one would expect from Hickling's more detailed work on the European species.

Apart from the seasonal variation in condition which this method is particularly adapted to show, there is superimposed upon it a secondary variation related to the length (here the mean length) of the fish. Older (longer) fishes tend to show a slightly lower level of condition throughout the seasonal cycle, consequent upon the increased metabolic strain of spawning. The point of inflexion on a curve showing this diminution of K with increasing length is thus a good approximate indication of the length at which sexual maturity is attained. Analogous findings in several other species of fishes could be quoted, but probably the best general exposition of the more important deductions to be derived from the study of K values is that given by Sir D'Arcy Thompson (1942, p. 194 et seq.).

In *M. hubbsi* the 'average'[1] values of K in relation to length of either sex are shown in Fig. 23. From this it can be seen that a majority of the males probably mature at a length of about 32 cm. (some certainly do so when still smaller), while it is probable that most of the females below 42 cm. length are immature. Considering this in conjunction with our previous findings of a difference of over 10 cm. between the sexes (in trawl-caught samples), it seems possible either that the males mature at least one year earlier than the females, or that the early growth rate of females is $1\frac{1}{4}$ times as fast as that of the males. The former is more probable, but the great scarcity of males over 50 cm. long, while females diminish in numbers more gradually to twice that length, makes it fairly certain that the growth rate of the *older* mature males is much lower than that of females of comparable size. Condition factors for males of 50 cm. and over were too few to include in any 'average' curve, but those we have (records of five individual fish) are all very low, suggesting complete analogy with

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[1] I use this expression 'average' to indicate values based on means of means, not on the arithmetic mean that would be derived from full integration of all the constituent data. This device is necessary here in order to eliminate the seasonal effect when studying the relation between length and ponderal index.

Hickling's (1933, pp. 43–4) observations on the very rapidly increasing metabolic strain of spawning among older males of European hake.

By selecting data from Appendix II c (samples in which five or more fish were weighed, northern and intermediate regions only, and working to mean dates) we can draw curves of the variation in K over the period covered by the observations, for either sex of *M. hubbsi*, as shown by the continuous lines in Fig. 24. Now these curves show a steep fall in the value of K during the summer, which tends to level out towards autumn. This is an almost certain indication that this hake is a summer spawner, as other species of hake elsewhere are known to be. All temperate fishes hitherto studied reach their peak of condition just prior to spawning, and some show very quick recovery from the loss occasioned by that act. Thus the seasonal cycle takes the form of a harmonic curve, and the relative steepness of the left- and right-hand sides of the 'wave' depends (*a*) upon the speed of recovery after

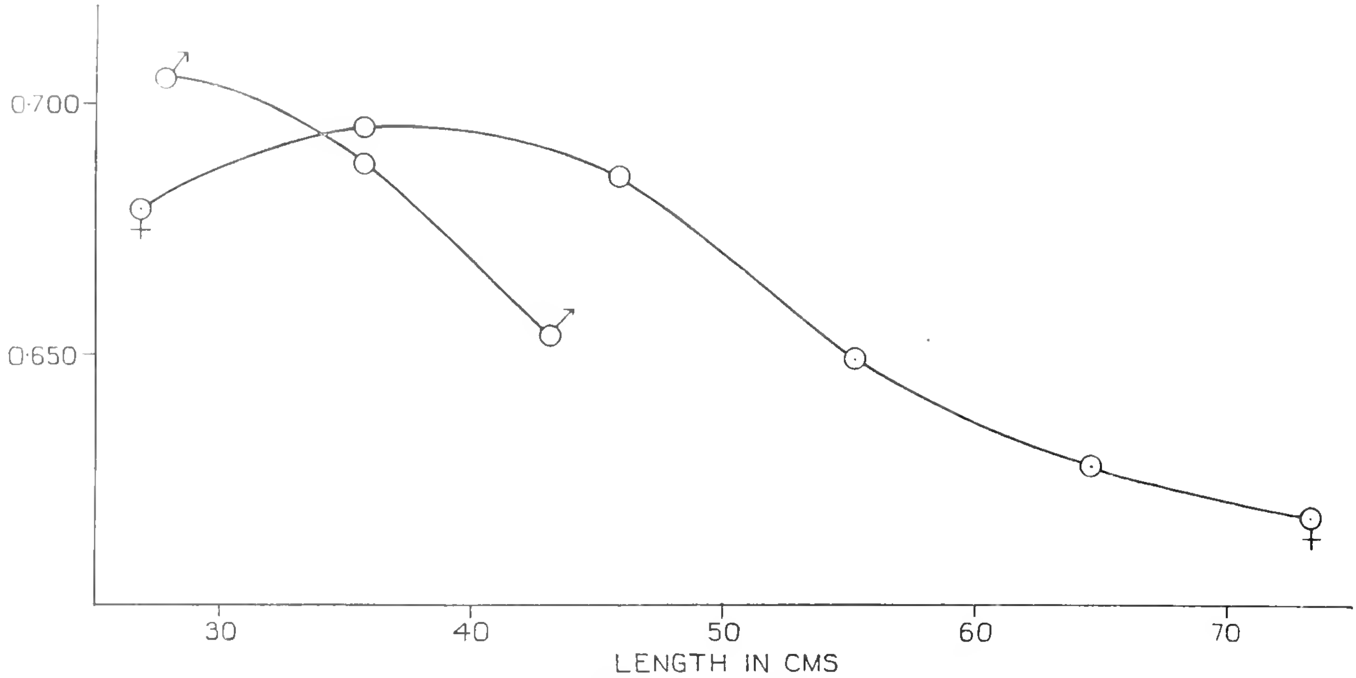

Fig. 23. Variation of 'average' K with length in male and female *Merluccius hubbsi*.

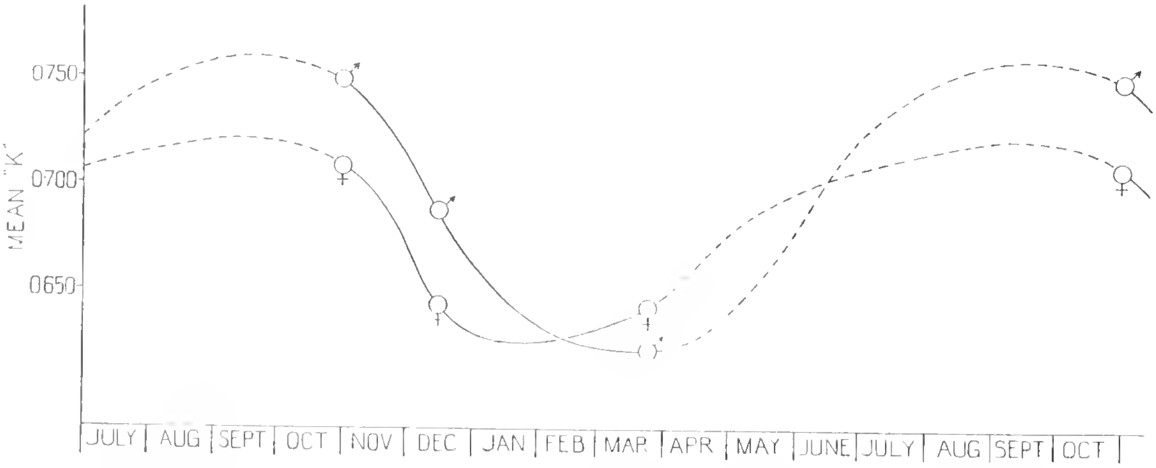

Fig. 24. Seasonal variation in the condition factor K of *Merluccius hubbsi*, for fish approximating to the mean length of either sex; for further explanation, see text.

spawning and (*b*) upon the extent to which spawning is limited in time. On the assumption that *M. hubbsi* conforms to this rule (as European hake are known to do), a purely hypothetical completion of the harmonic curves has been shown by the pecked lines in Fig. 24, for that part of the seasonal cycle for which we have no data.

Obviously such curves must regain a similar level for the beginning of the next seasonal cycle, and there are good grounds for belief that recovery after spawning is rapid, so that they will rise more steeply in autumn than in winter. The hypothetical portions of the curves are therefore almost certainly more accurate than might seem probable at first sight.

Before we proceed to a more detailed examination of the evidence provided by our ponderal indices, and their shortcomings, it may be pointed out that the generalized curves shown in Fig. 24 provide valid evidence of one important analogy with Hickling's findings on the European species—valid because it depends upon the portions of the curves derived from actual data and not from hypothesis. It can be seen that while the fall in condition of males and of females in early summer is nearly parallel, the females begin to recover first. The inference is that the spawning season of a majority of males is longer than that of a majority of the female fish. The agreement with Hickling's (1930*b*, pp. 33–4) observations on *M. merluccius* seems complete.

The generalized curves show a greater annual variation among males than among females. Since eggs are larger than sperms it might appear that this is anomalous, but it is probable that it is not so, for the following reasons: the smallest length classes of males contain a far higher proportion of mature fish than corresponding length classes of females, and as the male growth rate falls off the metabolic strain of spawning increases far more rapidly than in females (cf. Hickling, 1930*b*, p. 36; 1933, pp. 43–4). Consequently these curves show a greater annual variation among males just because they are generalized: the data for males include a greater proportion of spawning fish.

When we come to consider the seasonal variation in condition within individual length groups certain undoubted anomalies appear. In the following table the data used to compute the relation between K and length are also subdivided to show the means at mean dates within length classes. Several untoward features are at once apparent. Males of the 21–30 cm. length class showed greater seasonal variation than males of 31–40 cm., and females of the smaller length classes a greater seasonal range than larger females.

Table 14. *Variation in 'average'* K *of* Merluccius hubbsi *in relation to length, and seasonal variation of* K *within length classes*

(The left-hand columns are the data of Fig. 23.)

Length class	'True' mean length	'Average' K in relation to t	Mean K at mean dates within t classes		
			31 Oct.	16 Dec.	24 Mar.
			Males		
21–30	27·4	0·705	0·791	0·705	0·630
31–40	35·7	0·688	0·731	0·685	0·647
41–50	43·1	0·654	0·751	0·657	0·555
			Females		
21–30	26·8	0·678	0·736	0·677	0·621
31–40	35·8	0·695	0·767	0·647	0·671
41–50	45·9	0·685	0·747	0·667	0·641
51–60	55·3	0·649	0·686	0·636	0·624
61–70	64·7	0·628	0·662	0·614	0·608
71–80	73·4	0·618	0·633	0·621	0·600

The anomaly among the males mentioned above is almost certainly due to inclusion of an exceptionally large proportion of spawners of the smallest length class at one of the rich March hauls, with inadequate sampling in the earlier periods. The curious anomaly of 31–40 cm. females showing recovery by March, while smaller and larger fish did not, is probably due to inadequate sampling also. As it stands one would think it might indicate that some of this small group of mainly immature fish completed their cycle before their older sisters, and we know that the reverse is more generally true. However, there were indications of early shoreward movement among females of that length class in 1931–2, derived quite independently from this data, and it might be that our samples of it happened to include a majority of some year class which had got out of phase with the norm for the species, through exceptional conditions affecting them while still younger, or some such cause. In fishes with such a prolonged spawning season as hake non-conformity of this type is bound to occur from time to time, but to prove the point is quite another matter, and quite impossible with such limited data as ours.

The mere fact that mainly immature length classes showed a seasonal variation parallel to that for older fish need occasion no surprise, for Hickling (1935*b*) has established that a seasonal cycle foreshadowing the full sexual cycle of the adult takes place in immature European hake. The point is that the adult cycle should show the greater range. Here I believe that it is the limitation of our data in time that is at fault, and not insufficient sampling.

We have considerable evidence that larger females of *M. hubbsi* tend to move inshore earlier than smaller ones, and it is probable that they are normally the first to spawn (a feature well known among European hake). Now a generalized cycle such as the curve for females in Fig. 24 would only hold strictly for fish of the mean or 'average' length considered, the 41–50 cm. length class. Had we been able to obtain adequate figures for the whole year, it is probable that the whole cycle for the larger fish would have been found to be centred earlier in the year. If so, means for the end of October are not early enough to show the full extent of the annual variation in condition of these larger fish.

It is also possible that the anomaly shown by the females is not entirely due to the unavoidable limitations of our data, although I think there is little doubt that it was collected too late in the year to show up the peak period for the 51–60–70 cm. fish. In the first place, some *M. hubbsi* under 40 cm. long are mature. This would tend to increase the range of seasonal variation in mean values for the smaller length classes far above the range observed in European hake of similar length. In European hake, an altogether larger species, mature fish of such small size have only rarely been found. These were among a peculiar localized stock in the Clyde basin (Hickling, 1930*b*, pp. 52, 53 and Table VIa). A further likely source of discrepancy is that the sexual activity of the largest size groups may be reduced, or at any rate less regular, than in younger mature females. In European hake a reduction of sexual activity in the largest length groups, associated with reduced growth rate, was postulated by Belloc (1922, p. 40). Some concrete evidence in support of this view, relating to female hake of 90–100 cm., is given by Hickling (1930*b*, p. 29).

The condition factors of a few very large female *M. hubbsi* (over 90 cm. long) are extremely interesting. Unfortunately we only caught fish of this size in the southern region, so that the results are not strictly comparable with those previously tabulated; but it can be seen that all but the smallest of these very large fish showed very high values for K at a time of year when all the other females showed reduced values owing to spawning. These data are insufficient to be conclusive, but I believe that the oldest and largest female hake have reached a state of suspended sexual activity, and no longer show the seasonal variation in condition characteristic of younger fish (Table 15).

Table 15. *Condition factors of the largest* Merluccius hubbsi *weighed*

(*Note.* All were from deep water in the southern region.)

Station	Date	Weight	Length	K
		kg.	cm.	
WS817B	14. i. 32	6·100	94	0·734
WS818A	17. i. 32	7·300	100	0·730
WS819A	17. i. 32	5·000	92	0·642
WS819B	17. i. 32	7·400	96	0·836
WS820	18. i. 32	6·650	93	0·827

A similar phenomenon is suggested among fishes of other species: Tåning (1937, pp. 8, 23) has shown that the largest of the west Greenland cod do not take part in the return spawning migration to Icelandic waters which is characteristic of their slightly smaller sisters. It is certain that such spawning as occurs in Greenland waters themselves is on quite a minor scale; moreover, the extra large stationary west Greenland cod tend to be found near the extreme northern limit of the range of the species, where spawning does not occur. The analogy with our observations on the largest female *M. hubbsi* seems very close, and the suggestion that the latter are past spawning gains strength from the facts that males are scarce or absent from the most southerly waters where the large females are found, and that at no time have the latter been met with farther north.[1]

If the figures in the left-hand columns of Table 14, showing variation of K with length, are transposed to a percentage basis, it is possible to read off the correction to be applied to seasonal values for K (as plotted in Fig. 24), for fish of given mean length, working to the mid-point of each month. This has been done in Tables 16 (males) and 17 (females) for the length range likely to cover the mean lengths of any sizeable sample of *M. hubbsi*.

With the aid of these tables the *approximate* weight of any sample of fishes of known mean length can be calculated thus:

$$W = \frac{l^3}{100} \times K \times f,$$

where f is the number of fishes in the sample, the sexes being dealt with separately and the results summed. Some error is unavoidable, and these mean K values do not apply well to individual fishes. (Hake weights are too erratic to be dealt with individually, unless they are weighed gutted. Food may be snatched up in the trawl or stomachs may be evacuated, and their gorging habits are such that even 'in nature' the weights of any two fish of the same length at a given time might be expected to differ widely.)

An obvious source of error is the distance in time from the mid-point of the month in which the sample is taken, but equally obviously it is impracticable to tabulate K for every day of the year! Such derived values cannot take account of abnormal seasons. By using the tables given it has been found that with samples of ten or more fishes, using the formula for each sex separately, and checking against eighteen samples of which the actual weight was known, the 'theoretical' weights' mean gross error was 6·7%, with a range of $-16{\cdot}4$ to $+8{\cdot}4\%$. Further, it could be shown by summing the squared deviations from known weights that the derived values tabulated gave a better estimate than other average values for K, such as mean K for the whole year, either lumping the sexes or treating them separately. The range of error is great, but from a purely practical point of view it may be extremely valuable to know the probable *minimum* weight of catches where it was impossible to get actual weights in the field. For this reason 'theoretical' and 'probable minimum' weights for the unweighed catches of the first and second surveys have been calculated wherever the length data permit, and are tabulated along with the numbers of fishes in those catches in Appendices II A and

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[1] Of course they may be there at depths greater than we were able to fish.

IIB. The 'theoretical' weights are derived direct from the formula as explained above, *K* values being used from Tables 16 and 17; the 'probable minimum' weights are 18% less than these, i.e. I have assumed a probable maximum error of −18%.

An individual example of the potential value of *K* may be given from our richest haul of *M. hubbsi*. Here, at St. WS853, 1154 fish were captured in an hour. Of these, 943 were males and 211 females; all the females and 414 of the males were measured, and also weighed in 10 cm. length groups. The remaining males, 529 in number, were not measured, but were weighed in bulk. First let us see how far out our estimates of weight for this catch would have been, using the appropriate values for *K* given in Tables 16 and 17. 414 males had a mean length of 36·5 cm., and 529 males unmeasured, assuming the same mean length, give us a total of 943 males. *K* for March males of 36–37 cm. (Table 16) is 0·627. Hence the theoretical weight of the males is given by

Table 16. *Table of* K *for male* Merluccius hubbsi *throughout the year, computed as described in the text. Interpolated values in italics*

Length in cm.	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June
25·1–26·0	*0·744*	*0·771*	*0·799*	0·819	0·786	0·705	0·678	0·662	0·658	*0·669*	*0·693*	*0·718*
26·1–27·0	*0·742*	*0·770*	*0·797*	0·818	0·784	0·704	0·676	0·661	0·657	*0·668*	*0·692*	*0·717*
27·1–28·0	*0·742*	*0·769*	*0·797*	0·817	0·783	0·703	0·676	0·660	0·656	*0·668*	*0·691*	*0·716*
28·1–29·0	*0·742*	*0·769*	*0·797*	0·817	0·783	0·703	0·676	0·660	0·656	*0·668*	*0·691*	*0·716*
29·1–30·0	*0·740*	*0·768*	*0·795*	0·815	0·782	0·702	0·674	0·659	0·655	*0·666*	*0·690*	*0·715*
30·1–31·0	*0·739*	*0·766*	*0·793*	0·814	0·780	0·700	0·673	0·658	0·654	*0·665*	*0·688*	*0·713*
31·1–32·0	*0·735*	*0·762*	*0·789*	0·810	0·776	0·697	0·670	0·655	0·651	*0·662*	*0·685*	*0·710*
32·1–33·0	*0·733*	*0·760*	*0·787*	0·807	0·774	0·695	0·668	0·653	0·649	*0·660*	*0·683*	*0·707*
33·1–34·0	*0·727*	*0·754*	*0·781*	0·801	0·768	0·689	0·662	0·647	0·643	*0·654*	*0·677*	*0·702*
34·1–35·0	*0·722*	*0·749*	*0·775*	0·795	0·763	0·684	0·658	0·643	0·639	*0·650*	*0·673*	*0·697*
35·1–36·0	*0·716*	*0·743*	*0·769*	0·789	0·756	0·679	0·652	0·638	0·634	*0·645*	*0·667*	*0·692*
36·1–37·0	*0·709*	*0·735*	*0·761*	0·781	0·749	0·672	0·646	0·631	0·627	*0·638*	*0·660*	*0·685*
37·1–38·0	*0·701*	*0·727*	*0·752*	0·772	0·740	0·664	0·638	0·624	0·620	*0·631*	*0·653*	*0·677*
38·1–39·0	*0·692*	*0·718*	*0·743*	0·762	0·731	0·656	0·630	0·616	0·612	*0·622*	*0·645*	*0·668*
39·1–40·0	*0·683*	*0·708*	*0·733*	0·752	0·721	0·647	0·622	0·608	0·604	*0 614*	*0 636*	*0·659*
40·1–41·0	*0·671*	*0·696*	*0·720*	0·739	0·709	0·636	0·611	0·597	0·594	*0·604*	*0·625*	*0·648*
41·1–42·0	*0·660*	*0·684*	*0·709*	0·727	0·697	0·626	0·601	0·588	0·584	*0·594*	*0·615*	*0·637*
42·1–43·0	*0·649*	*0·673*	*0·697*	0·715	0·685	0·615	0·591	0·578	0·574	*0·584*	*0·605*	*0·627*
43·1–44·0	*0·640*	*0·664*	*0·688*	0·705	0·676	0·607	0·583	0·570	0·567	*0·576*	*0·596*	*0·618*
44·1–45·0	*0·634*	*0·658*	*0·681*	0·697	0·670	0·601	0·578	0·565	0·561	*0·571*	*0·591*	*0·613*
45·1–46·0	*0·629*	*0·653*	*0·676*	0·693	0·665	0·597	0·573	0·560	0·557	*0·566*	*0·586*	*0·608*
46·1–47·0	*0·624*	*0·647*	*0·670*	0·687	0·659	0·592	0·569	0·556	0·552	*0·562*	*0·581*	*0·603*
47·1–48·0	*0·623*	*0·646*	*0·669*	0·686	0·658	0·590	0·567	0·554	0·551	*0·560*	*0·580*	*0·601*
48·1–49·0	*0·621*	*0·643*	*0·666*	0·683	0·655	0·588	0·565	0·553	0·549	*0·558*	*0·578*	*0·599*
49·1–50·0	*0·618*	*0·641*	*0·664*	0·681	0·653	0·586	0·563	0·551	0·547	*0·556*	*0·576*	*0·597*
50·1–51·0	*0·617*	*0·640*	*0·662*	0·679	0·651	0·585	0·562	0·549	0·546	*0·555*	*0·575*	*0·596*
51·1–52·0	*0·615*	*0·638*	*0·661*	0·678	0·650	0·583	0·561	0·548	0·545	*0·554*	*0·573*	*0·594*
52·1–53·0	*0·614*	*0·637*	*0·660*	0·677	0·649	0·583	0·560	0·547	0·544	*0·553*	*0·573*	*0·594*
53·1–54·0	*0·614*	*0·637*	*0·659*	0·676	0·648	0·582	0·559	0·547	0·543	*0·553*	*0·572*	*0·593*
54·1–55·0	*0·614*	*0·637*	*0·659*	0·676	0·648	0·582	0·559	0·547	0·543	*0·553*	*0·572*	*0·593*
55·1–56·0	*0·613*	*0·636*	*0·659*	0·675	0·648	0·581	0·559	0·546	0·543	*0·552*	*0·571*	*0·592*
56·1–57·0	*0·613*	*0·636*	*0·659*	0·675	0·648	0·581	0·559	0·546	0·543	*0·552*	*0·571*	*0·592*
57·1–58·0	*0·612*	*0·635*	*0·658*	0·675	0·647	0·581	0·558	0·545	0·542	*0·551*	*0·571*	*0·591*

$$W = \frac{36{\cdot}5^3}{100} \times 0{\cdot}627 \times 943 \text{ g.}$$

$$= 486{\cdot}27 \times 0{\cdot}627 \times 943 \text{ g.}$$

$$= 304{\cdot}89129 \times 943 \text{ g.}$$

$$= 287{,}512{\cdot}48647 \text{ g., say } \mathbf{287{\cdot}5} \text{ kg.}$$

211 females had a mean length of 41·4 cm. *K* for March females of 41·1–42·0 cm. (Table 17) is 0·695. Hence the theoretical weight of the females is given by

$$W = \frac{41{\cdot}4^3}{100} \times 0{\cdot}695 \times 211 \text{ g.}$$

$$= 709{\cdot}56 \times 0{\cdot}695 \times 211 \text{ g.}$$

$$= 493{\cdot}14420 \times 211 \text{ g.}$$

$$= 104{,}053{\cdot}4262 \text{ g., say } \mathbf{104{\cdot}1} \text{ kg.}$$

Table 17. *Table of* K *for female* Merluccius hubbsi *throughout the year, computed as described in the text. Interpolated values in italics*

Length in cm.	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June
34·1–35·0	*0·759*	*0·777*	*0·796*	0·799	0·789	0·750	0·720	0·700	0·694	*0·698*	*0·714*	*0·735*
35·1–36·0	*0·761*	*0·778*	*0·798*	0·801	0·791	0·752	0·721	0·702	0·696	*0·700*	*0·715*	*0·736*
36·1–37·0	*0·762*	*0·780*	*0·799*	0·802	0·792	0·753	0·723	0·703	0·697	*0·701*	*0·716*	*0·738*
37·1–38·0	*0·763*	*0·781*	*0·800*	0·803	0·793	0·754	0·723	0·704	0·698	*0·702*	*0·717*	*0·739*
38·1–39·0	*0·763*	*0·781*	*0·800*	0·803	0·793	0·754	0·723	0·704	0·698	*0·702*	*0·717*	*0·739*
39·1–40·0	*0·762*	*0·780*	*0·799*	0·802	0·792	0·753	0·723	0·703	0·697	*0·701*	*0·716*	*0·738*
40·1–41·0	*0·762*	*0·779*	*0·798*	0·801	0·791	0·752	0·722	0·702	0·696	*0·700*	*0·716*	*0·737*
41·1–42·0	*0·760*	*0·777*	*0·797*	0·800	0·790	0·751	0·720	0·701	0·695	*0·699*	*0·714*	*0·736*
42·1–43·0	*0·759*	*0·776*	*0·795*	0·798	0·788	0·750	0·719	0·700	0·694	*0·698*	*0·713*	*0·734*
43·1–44·0	*0·757*	*0·774*	*0·793*	0·796	0·786	0·748	0·717	0·698	0·692	*0·696*	*0·711*	*0·732*
44·1–45·0	*0·755*	*0·772*	*0·791*	0·794	0·784	0·746	0·715	0·696	0·690	*0·694*	*0·709*	*0·731*
45·1–46·0	*0·753*	*0·770*	*0·789*	0·792	0·782	0·744	0·713	0·694	0·688	*0·692*	*0·707*	*0·728*
46·1–47·0	*0·750*	*0·768*	*0·787*	0·790	0·780	0·741	0·711	0·692	0·686	*0·690*	*0·705*	*0·726*
47·1–48·0	*0·749*	*0·766*	*0·786*	0·789	0·778	0·740	0·710	0·691	0·685	*0·689*	*0·704*	*0·725*
48·1–49·0	*0·746*	*0·763*	*0·782*	0·785	0·775	0·737	0·707	0·688	0·682	*0·686*	*0·701*	*0·722*
49·1–50·0	*0·743*	*0·760*	*0·779*	0·782	0·772	0·734	0·704	0·685	0·679	*0·683*	*0·698*	*0·719*
50·1–51·0	*0·740*	*0·757*	*0·776*	0·779	0·769	0·731	0·701	0·682	0·677	*0·681*	*0·695*	*0·716*
51·1–52·0	*0·737*	*0·754*	*0·773*	0·776	0·766	0·728	0·699	0·680	0·674	*0·678*	*0·693*	*0·713*
52·1–53·0	*0·734*	*0·751*	*0·769*	0·772	0·763	0·725	0·696	0·677	0·671	*0·675*	*0·690*	*0·710*
53·1–54·0	*0·731*	*0·748*	*0·766*	0·769	0·760	0·722	0·693	0·674	0·668	*0·672*	*0·687*	*0·708*
54·1–55·0	*0·728*	*0·745*	*0·763*	0·766	0·756	0·719	0·690	0·671	0·666	*0·670*	*0·684*	*0·705*
55·1–56·0	*0·725*	*0·742*	*0·760*	0·763	0·753	0·716	0·687	0·669	0·663	*0·667*	*0·681*	*0·702*
56·1–57·0	*0·723*	*0·739*	*0·758*	0·761	0·751	0·714	0·685	0·667	0·661	*0·665*	*0·679*	*0·700*
57·1–58·0	*0·720*	*0·736*	*0·755*	0·758	0·748	0·711	0·682	0·664	0·658	*0·662*	*0·676*	*0·697*
58·1–59·0	*0·718*	*0·734*	*0·752*	0·755	0·746	0·709	0·680	0·662	0·656	*0·660*	*0·674*	*0·695*
59·1–60·0	*0·715*	*0·731*	*0·749*	0·752	0·742	0·706	0·677	0·659	0·653	*0·659*	*0·672*	*0·692*
60·1–61·0	*0·712*	*0·729*	*0·747*	0·750	0·740	0·704	0·675	0·657	0·651	*0·655*	*0·669*	*0·690*
61·1–62·0	*0·709*	*0·726*	*0·744*	0·747	0·737	0·701	0·672	0·654	0·649	*0·652*	*0·667*	*0·687*
62·1–63·0	*0·707*	*0·723*	*0·741*	0·745	0·735	0·699	0·670	0·652	0·647	*0·650*	*0·665*	*0·684*
63·1–64·0	*0·706*	*0·723*	*0·741*	0·744	0·734	0·698	0·670	0·652	0·646	*0·650*	*0·664*	*0·684*
64·1–65·0	*0·704*	*0·720*	*0·737*	0·741	0·731	0·695	0·667	0·649	0·643	*0·647*	*0·661*	*0·681*

Thus the gross weight of the whole sample should 'theoretically' be **391·6** kg., or, deducting 18 % to get our 'probable minimum' weight, we should say that at the very least **321** kg. of hake had been taken.

The actual weights recorded at St. WS853 were:

414 males (weighed in 4 length groups) totalled	121·350 kg.
529 males unmeasured, weighed in bulk	155·000 kg.
211 females (weighed in 6 length groups) totalled	**103·290** kg.
Grand total	**379·640** kg.

and the total for males alone, for comparison with the first calculation above, was **276·350** kg.

From these it can be seen that the theoretical weights, using mean monthly figures for *K* from the tables, gave errors of:

+11·15/276·35 kg., or +4·07% for males,
+0·81/103·29 kg., or +0·78% for females,
+11·96/379·64 kg., or +3·15% for the total sample,

but consideration of the 'probable minimum' weight would have saved us from any over-optimism. Converting to units used among British practical fishermen, our theoretical 'guess' at the catch would have been less than 2 stone too big in a catch of 7½ cwt., and our cautious 'probable minimum weight' would have involved the statement that the catch was at least 708 lb. or 6⅓ cwt., instead of the 7½ cwt. that we happen to know that it was.

Another way in which the ponderal index *K* can assist us is well shown by the figures for this station: the actual weights of the 414 measured males being known, 'true' mean *K* for them can be computed for this individual catch thus:

$$K = \frac{w}{l^3} \times 100 = \frac{293{\cdot}116}{48627} \times 100 = \mathbf{0{\cdot}603}.$$

Now we have the bulk weight of the 529 unmeasured males, and if we calculate their theoretical weight from this figure, assuming the same mean length as the measured subsample, and find good agreement between theoretical and actual weights, we have a good argument that our assumption as to length is justified, thus:

$$W = \frac{l^3}{100} \times K \times 529 = 486{\cdot}27 \times 0{\cdot}603 \times 529 \text{ g.} = \mathbf{155{\cdot}114} \text{ kg.},$$

in fact we know that they weighed **155** kg., and the agreement is so close that there is little doubt the unmeasured subsample really had a mean length almost identical with that of the measured one.

MIGRATIONS

We have seen that the seasonal changes in condition of *M. hubbsi* correspond to those that occur in European hake. Variation in condition is primarily connected with the sexual cycle, and since the main inshore movement of European hake is a spawning migration, it was expected that the movements of Patagonian hake would also correspond with those of the better-known species. It was by no means easy to demonstrate this from our scattered data. The necessity for investigating the whole area as fully as possible prevented us from repeating observations within more localized portions to the extent desirable when trying to follow the seasonal movements of a single species.

One of the most valuable features discovered by Hickling in his work on European hake was a direct relation between increase in depth and size of fish, which may be locally reversed at the time when the larger fish are moving inshore. By watching the seasonal variation in size over limited ranges of depth one may thus obtain valuable clues as to seasonal movements. But the peculiar topography of the Patagonian Continental Shelf, with its uniform depths prevailing over vast distances, was found to defeat this method of attack. Although correlations were found between depth and size of the fish, and these showed the change of sign with the seasons that one would expect if they moved in a fashion analogous to that of the European species, the correlations were not large enough to be considered significant. The slight gradient of the Patagonian shelf thus masks a feature that is beautifully clear off western Europe, where the shelf slopes more steeply and the edge is less abruptly defined, giving a more continuous depth gradient in most localities.

However, the distribution of exceptionally rich hauls of *M. hubbsi* clearly indicated the possibility of seasonal migrations similar to those of *M. merluccius*, and eventually it was found that this could be shown with some certainty when relative abundance and size differences were considered in relation to distance from the mainland coast. It was necessary further to restrict the data to be considered, so as to follow the changes within limited areas (the northern and intermediate regions considered separately), for it is well known that such movements may take place at different times in different parts of the range of a widely distributed species.

In the **northern region**, three series of observations at different seasons seem together to give reasonably good evidence of shoreward movement in summer, and will now be described in some detail.

In October-November there are data from nine stations that can be arranged according to their distance from the coast, and which were completed within a reasonably narrow interval of time (see Table 18).

Table 18. Merluccius hubbsi *captures between 15 October and 3 November 1931 in the northern region, with their distance from the coast*

Station	Depth m.	Distance offshore sea miles	Numbers of hake: Males	Numbers of hake: Females	Total hake, remarks
WS762A	66	14	0	0	0
WS762B	66	10	0	0	3 juv. in accessory net
WS777	98	43	0	0	0 (torn)
WS763	85	75	?	?	15 not sexed, some juv.
WS771	90	130	41	50	91
WS764A	108	145 }	12	15	27
WS764B	107	140 }			
WS765	116	212	11	16	27
WS772	236	236	0	9	9

Consideration of the lengths of the females, together with the distance intervals, seemed to justify a further lumping of these data, to the form shown in Table 19.

Table 19. *Summary of October-November data bearing on hake movements in the northern region*

Distance offshore sea miles	Total hake	Hours trawling (no. of hauls)	Hake per hour	Males: No.	Males: Mean length	Females: No.	Females: Mean length	Sex ratio
Less than 100 miles	18	3 (3)	6	—	—	—	—	?
100–200 miles	117	3 (3)	39	53	35·8	65	43·5	45% ♂♂
Over 200 miles	36	1¼ (2)	28	11	32·4	25	50·1	30% ♂♂

From these two tables it seems fairly clear that at this time of the year the hake were mainly concentrated more than 100 miles from the coast. A shoreward movement may have begun. (St. WS771, the richest of this series, was the innermost of the three between 100 and 200 miles offshore.) The length data do not help here; one would not expect the smaller females to head the advance, and in fact the size distribution might well be indicative of a prolongation of winter conditions. The offshore males were too few for the size difference to be considered significant for that sex. However, the sex ratios suggest the beginnings of concentration shoreward, and it is possible that bigger females catch up and pass the smaller ones later. (There is considerable diffuse evidence that the speed and extent of migratory movement is a function of size of fish.)

In December there were only six stations suitable for this comparison, but at three of them additional 4-hr. hauls were made, so that there is a considerable body of data over the most critical part of the distance range. The whole series of observations was completed between 13 and 16 December 1931, so that there is little chance of the comparison being vitiated by the time factor.

Table 20. *December data bearing on hake movements in the northern region*

Station	Depth m.	Distance offshore sea miles	Hake nos.			Hours trawling (no. of hauls)	Hake per hour	Mean length		Sex ratio % males
			Males	Females	Total and remarks			Males	Females	
WS788	85	27	4	2	6 (+24 juv.)	1 (1)	6 (+24)	37·8	60·8	66
WS789	94	53	5	6	11	1 (1)	11	30·6	61·7	45
WS790 A+B	100	85	58	319	377 (+5 juv.)	5 (2)	75 (+1)	31·8	51·2	18
WS791 A+B	97	121	53	150	203	5 (2)	40	31·9	43·3	26
WS792 A+B	107	147	13	74	87	5 (2)	17	36·8	54·6	15
WS793	110	175	0	7	7	1 (1)	7	—	54·0	0

The results are summarized in Table 20, and show that the greatest concentration was at St. WS 790, 85 miles offshore. The length data for males are again unsatisfactory because of the wide dispersion and smallness of the samples containing the larger fish. I suspect that the males were still widely dispersed, as is suggested by the low sex ratios at the richer stations. Here the female length data are very interesting, the mean length at the peak station being considerably higher than at the richest station of the earlier series, although 45 miles farther inshore. Thus

$$\text{Mean length } ♀\text{, WS790 A+B} = 51{\cdot}2, \quad \frac{\sigma^2_M}{N} = 0{\cdot}4672,$$

$$\text{Mean length } ♀\text{, WS771} = 44{\cdot}0, \quad \frac{\sigma^2_M}{N} = 0{\cdot}9488.$$

Difference $d = 7{\cdot}2$ cm.

$$\sigma d = \sqrt{(0{\cdot}4672 + 0{\cdot}9488)} = \sqrt{1{\cdot}416} = 1{\cdot}19,$$

$$\frac{d}{\sigma_d} = \frac{7{\cdot}2}{1{\cdot}19} = 6{\cdot}05. \text{ Strongly significant.}$$

This agrees well with the view that larger females may catch up and pass the smaller ones on their way inshore. But, considering the December figures alone, we find that at St. WS791 A+B the females were significantly smaller than those on either side of them; the relation of length to distance offshore is discontinuous. The detailed length-frequency distributions showed that this was due to a much higher proportion of immature fish, especially of about 30–32 cm. length, at St. WS791. It would seem that large females are definitely heading the shoreward movement at this time, a few having penetrated right inshore among the juveniles, which are perhaps almost non-migratory. Comparison with the October-November results suggests that in the interim (about 7 weeks, taking mean dates) the large fish have travelled shorewards some 100 miles, while the smaller fish advanced some 15 miles only.

In March also there were only six stations providing comparable data from the northern region, but fortunately five of these yielded rich hauls. The remaining station, WS 860, presents some anomalies that spoil an agreement with our theory that is otherwise complete; for a small number of large hake were found less than 100 miles from the mainland, where a good haul of small hake should have been taken. It is probable, however, that the net did not fish properly at this station. A note in Gunther's hand in the original rough log reads: 'Haul disappointingly small. A few hake escaped. Those present of large size—majority caught in after wing which opens suspicion that net may have been fishing foul.' Possibly, therefore, we should be justified in disregarding the results from this anomalous station as 'not strictly comparable'. The data from the series as a whole, however, appear to fall quite naturally into inshore and offshore groups, and when so lumped the doubtful result from St. WS860 is completely swamped by the more abundant data from the other two inshore stations.

Table 21. *March data bearing on hake movements in the northern region* (21–25 *March* 1932)

Station	Depth m.	Distance offshore sea miles	Hake nos.			Hake per hour	Mean lengths		Sex ratio % males
			Males	Females	Total, and remarks		Males	Females	
WS853	90	44	943	211	1154 (only 414 ♂♂ measured)	1154	36·4	41·5	81·7
WS860	102	77	5	16	21 (? net foul)	21	38·0	54·6	29·4
WS855	112	80	130	120	250	250	33·8	37·8	52·0
WS859B	108	142	64	42	106	106	38·5	45·9	60·4
WS859A	108	146	113	82	195	195	38·9	45·3	57·9
WS858	127	212	28	62	90	90	40·9	50·3	31·1

The data from individual stations are shown in Table 21. The very large catch at St. WS853, the station nearest the land, was the best we obtained at any time. The hake here were of small size, but some were ripe, and the high proportion of males was also noteworthy. It would seem clear that the smallest mature females are the last to spawn in any given season.

Table 22. *The March data combined into inshore and offshore groupings*

Distance offshore sea miles	Total hake	Hours trawling (no. of hauls)	Hake per hour	Males		Females		Sex ratio
				Nos.	Mean length	Nos.	Mean length	
Less than 100	1425	3 (3)	475	549*	35·8	349	40·7	75
More than 140	391	3 (3)	130	205	39·0	186	47·1	52

* 529 males were not measured at St. WS853, the number given refers only to the measured specimens upon which the mean length given is based; hence the discrepancy with the 'total' column.

The combined data (Table 22) show very clearly that smaller fish predominated in the inshore catches and that the proportion of males was higher inshore. The differences in mean lengths are strongly significant by the usual statistical tests. Comparison with the December figures (Table 20) indicates that a complete change in the hake population had taken place; in March, at the inshore stations, the females were much smaller and the males larger than in December. Another striking feature of the March results is the high sex ratios—even at the offshore stations the proportion of males was much higher than earlier in the year. This is probably due to the main concentration for spawning being later in the summer than exact correspondence with the habits of the European species would demand. Thus the larger offshore fishes were probably only just beginning to disperse after spawning. In this respect *M. hubbsi* may come closer to *M. bilinearis* (where the correlation between shoreward concentration and the peak of annual temperature is very strong) than to *M. merluccius*, where the first wave of larger spawners moves inshore at least two months before the maximum temperatures are reached, and the second wave contains many immature fishes. (It should be borne in mind that the *range* of temperature is much greater in the habitat of *M. bilinearis* than in that of *M. merluccius*.) The timing of the cycle of movement of *M. hubbsi* is probably connected with that lateness of the whole 'plankton calendar' of these southern waters, which was described in the introductory section of this paper. It is not likely to be a direct effect of temperature (as seems possible with *M. bilinearis*), for the range of temperature here is small, approaching British conditions more closely than New England conditions.

The broad fact that smaller fish are still closely congregated inshore, while large fish are beginning to disperse offshore, seems sufficiently clear for us to state that the March results are consistent with the view that the seasonal movement of *M. hubbsi* is essentially similar to that of other species of hake elsewhere. Ponderal indices also support this view: the small inshore population, with a probable majority of late spawners and immatures, showed average *K* 20% higher than that of the larger offshore population sampled at the same time. The latter must have completed spawning, for they showed the lowest average *K* values (around 0·550) recorded at any season.

In the Intermediate Region data covering more of the annual cycle are available, if we may consider results obtained in different years as roughly comparable for our present purpose, but they are scantier and less satisfactory than those from the northern region. We have already seen that the hake diminish in numbers towards the south, so that this difficulty was only to be expected.

In October and November no satisfactory series of observations was obtained here, but the size and abundance of the hake at two stations, WS773 and 775, 206 and 82 miles off the land respectively, were consistent with the view that a winter type of distribution still prevailed. Hake were nearly twice as numerous at the offshore station where they were very much larger than those found farther in. The proportion of males was greater inshore. Twenty-two juvenile hake of indeterminate sex, less than 20 cm. long, were also captured during this period. This was at St. WS776, 60 miles from the land.

In December numerous observations were obtained during the third survey, but they were too scattered, and the samples too small, to warrant individual treatment of the results. When the stations are grouped according to their distance from the coast, the picture of frequency distribution obtained is in accordance with more conclusive results from farther north at the same season. It therefore seemed legitimate to use similarly grouped data in studying the size distribution, etc., since although either chain of evidence may appear bald and unconvincing by itself, they corroborate each other.

Table 23. *December data bearing on hake movements in the intermediate region, 5 to 22 December* 1931

Distance grouping sea miles from mainland coast	Actual mean distance	Hours trawling	Hake nos.			Hake per hour	Mean lengths		Sex ratio % males
			Males	Females	Total		Males	Females	
I, 0–49	35	6	34	77	111	18	33·1	41·9	30·6
II, 50–99	75	6	17	134	151	25	31·9	45·7	11·3
III, 100–149	129	12	20	219	239	20	?*	56·8	8·4
IV, 150–199	161	3	1	25	26	9	42·0	58·6	3·8
V, over 200	219	2	0	17	17	8	—	55·5	0·0

* The mean would be misleading here (see text).

These data are summarized in Table 23. It will be seen that the relative abundance was greatest between 50 and 99 miles from the coast, and that the proportion of males was highest close in to the land. The length data for males are unsatisfactory owing to wide dispersion in the small samples. In distance grouping III a mean length for males would be meaningless, for the sample was composed of some very small and a few large fish with intermediate lengths entirely unrepresented. The more abundant length data for females tell a consistent story: the differences in mean lengths of the two inshore groups from all the offshore groups are significant. The inshore fish were smaller, and the offshore population apparently very homogeneous at this time.

Here, then, we have the suggestion that shoreward concentration is beginning, but is not yet so well defined as in the northern region at the same period.

A few January observations, quite insufficient by themselves, fit in so well with the general theory that I give them here in full (Table 24) and have included them in the general diagrammatic summary of the observations on hake movement in Fig. 25. Following on the December observations these few January stations clearly suggest an increase in the tendency to shoreward concentration. This seems mainly due to an incursion of larger females (just as we should expect), for the difference in mean length of over 5 cm. between the peak station WS809 and the inshore figures for distance grouping II of the previous month is strongly significant.

Table 24. *Observations from 7 to 9 January 1932, to be considered with the December data bearing on hake movements in the intermediate region*

Station	Distance offshore sea miles	Hours trawling (no. of hauls)	Hake nos.			Hake per hour	Mean lengths		Sex ratio
			Males	Females	Total		Males	Females	
WS810	20	1 (1)	0	2	2	2	—	37·0	0
WS809 A + B	52	5 (2)	7	69	76	15	30·7	51·4	9·2
WS808	77	1 (1)	0	3	3	3	—	58·0	0
WS807	104	1 (1)	0	0	0	0	—	—	—

Some observations made in April during the first survey are also in very good agreement with the theory. Catches were more uniform than they were during the peak of shoreward movement (in March, only northern region data available), and the distribution in relation to distance from the land was bi-modal. The hake were most abundant at two distinct points over the range observed, at 94 and 238 miles from the land, the former being the richer haul and composed of significantly smaller fishes. A distribution of this type is just what one would expect if there had been a double wave of shoreward movement, and if in April (autumn) the fish were again moving offshore towards their winter quarters. We have already seen that the larger fish get farther out than the small ones, except at midsummer, and they must therefore lead in the offshore movement, just as they seem to catch up and pass the smaller fishes during the season of shoreward movement. The April data are shown in detail in Table 25.

Table 25. *April data bearing on hake movements in the intermediate region,* 17 *to* 25 *April* 1927

Station	Distance offshore sea miles	Depth m.	Hake nos.			Mean lengths		Sex ratio % males
			Males	Females	Total per hour	Males	Females	
WS96	34	96	14	16	30	30·0	33·7	46·7
WS95	68	104	10	29	39	39·4	43·4	25·6
WS108	94	119	62	66	128	35·6	43·6	48·4
WS97	165	146	14	20	34	38·1	57·8	41·2
WS98	238	172	11	60	71	39·4	53·6	15·5
WS99	285	237	0	19	19	—	63·3	0·0

Another point brought out by this table is the relatively greater abundance of males than at any other season except March, and their tendency not to go so far offshore as the larger females.

The differences in mean length for either sex at the two peak stations are significant by the usual d/σ_d test, which has been applied throughout this section wherever differences in mean length have been considered specifically. I have not tabulated σ or σ_M^2/N for all the means, because many of them did not individually assist in the building up of the general picture.

Finally, during the second survey, a series of observations in June (midwinter) yielded two rich hauls at the greatest distance offshore, while farther in there were few hake, and only a singleton within 100 miles of the land. These results also showed that, as at all times except midsummer, the mean lengths of the more adequate samples increased with their distance from the coast, and at the same time the proportion of males diminished.

Table 26. *June data bearing on hake movements in the intermediate region*, 1 *to* 8 *June* 1928

Station	Distance offshore sea miles	Depth m.	Hake nos.			Mean lengths		Sex ratio % males
			Males	Females	Total per hour	Males	Females	
WS222	29	103	0	1	1	—	59·0*	0
WS223	95	114	0	0	0	—	—	—
WS220	126	106	3	3	6	44·7*	43·0*	50
WS219	134	115	16	26	42	36·8	40·7	38
WS216	197	176	87	181	268	40·1	47·5	32
WS217	221	146	118	294	412	39·4	46·5	29

* Too few for means to have any significance.

CONCLUSIONS ON MIGRATION

The relative abundance of the hake caught in relation to distance from the coast is the best means of studying the probable seasonal movements of *M. hubbsi*, from our unavoidably limited data. For comparative purposes the catches per hour for each series of observations may be summed, and the catch at each distance category expressed as a percentage of the figure so obtained. A diagrammatic summary of the seasonal observations, obtained in this way, is shown in Fig. 25.

We have seen also that comparisons of mean lengths and sex ratios corroborate the general picture so obtained, wherever the data are adequate.

M. hubbsi seems to migrate towards the coast in summer, and offshore in winter, in much the same way as do better known species of hake elsewhere. It would seem that as in *M. merluccius*, the larger females move inshore first, passing their smaller sisters who may, however, begin to shoal somewhat earlier. There is a strong suggestion that the smaller fish are rarely abundant at the greater distances from the coast; probably they do not migrate so far or so fast as the bigger ones. This may be a function of size, and not only due to the greater proportion of immature fish among the smaller individuals, for the proportion of males always diminished as one proceeded seawards, and in this species, where the disparity in size between the sexes is much more marked than in *M. merluccius*, it is certain that many of the males of even the smallest length class are mature. Probably the movements of males show some marked differences from those of the females: the proportion of males was noticeably high in March, at the time of greatest shoreward concentration of the smaller females, still fairly high when seaward movement had begun in April, and low at all other seasons. This suggests that, except at the height of the breeding season and for a short period afterwards, the males are more widely dispersed, and less inclined to shoal, than are the females.

Although *M. hubbsi* seems to move shorewards in a double wave rather like *M. merluccius*, this movement begins later in the year, and in this respect perhaps resembles more closely the movement of *M. bilinearis*. It is thought that this is probably connected with the general lateness of the biological seasons in this part of the southern hemisphere, which has been described in the introduction to this report. In *M. bilinearis* the later timing of the cycle may well be a direct effect of temperature, for off New England the annual range is great. It is unlikely to be so off Patagonia, where the annual cycle of temperature, though on a rather low level, shows small annual range. Thus the temperature conditions in the habitat of *M. hubbsi* resemble more closely those found on the European seaboard of the North Atlantic (see also the Hydrological Notes in the Introduction).

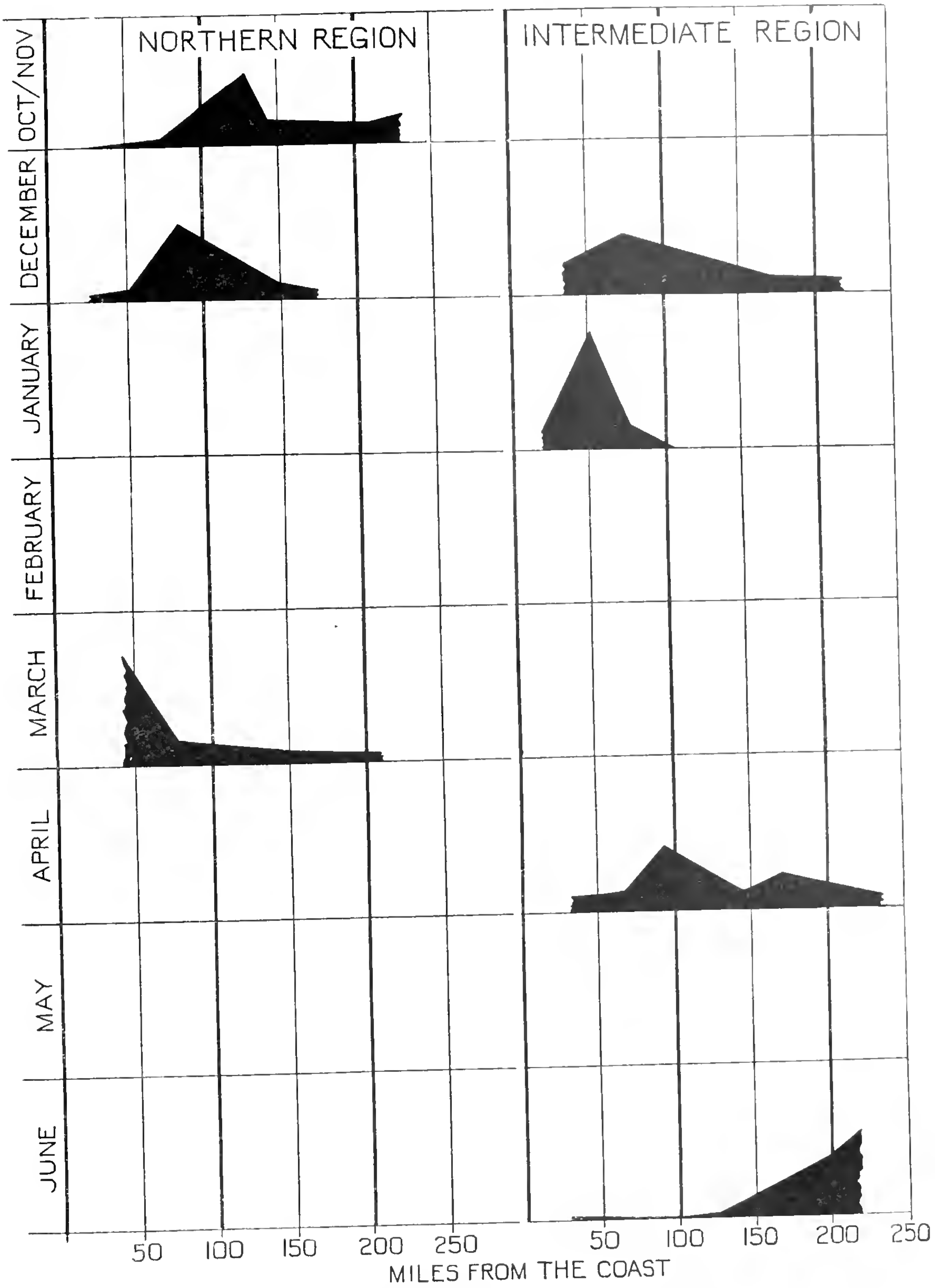

Fig. 25. Diagram showing seasonal variation in relative abundance of *Merluccius hubbsi* at different distances from the coast.

THE FOOD AND FEEDING OF *MERLUCCIUS HUBBSI*

Owing to the wide scope of the survey programme it was not possible to carry out such detailed observations on this subject as have been found desirable by European specialists working on single species of fish (e.g. Hardy (1924) on herring, Hickling (1927) on hake). On our first survey 191 stomachs were examined and on the second 186. On the third survey forty-six notes on stomach contents were made in the field, but owing to pressure of other work the numbers of fish examined in this way were not always recorded. It was evident, however, that the proportion of fish containing food was least in summer, which accords with the known habits of European hake (Hickling, 1927, p. 49). A general loss of appetite just prior to spawning is known among many diverse species of fishes.[1]

Our first survey (autumn) and second survey (winter) results show that a slightly higher proportion of Patagonian hake were found to contain food in winter, but I do not believe this indicates more extensive feeding during that season. From notes on the size and numbers of food organisms in individual stomachs it is evident that feeding was heaviest in autumn. The apparent anomaly is due partly to a seasonal change in diet, partly, no doubt, to the limitations of the data.

The number of times that food of recognizable categories was recorded, and the percentage occurrence of each category, during each survey are set out in Table 27. From this it is at once apparent that the feeding habits of *M. hubbsi* are essentially similar to those of *M. merluccius*, and perhaps even closer to those of *M. bilinearis* (Bigelow and Welsh, 1925, pp. 389–90). It feeds chiefly upon other fishes, including even its own species, squids and more or less planktonic crustacea. This last constituent was chiefly found in the stomachs of the smaller and younger fish.

The list of fishes eaten includes the commonest species of the area. Falkland herring (*Clupea fuegensis*) was by far the most important forage species, especially in winter, but other species are preyed upon with equal voracity when readily available. Thus as many as sixty-seven individuals of the small scald-fish *Thysanopsetta naresi* have been taken from the stomach of a hake less than 56 cm. long. *Merluccius hubbsi*, like other species of hake, are known to devour individuals of their own kind more than half their own length. Had we been able to obtain more food records during the offshore phase of the seasonal migration there is little doubt that such instances would have been commoner.

There is one peculiar difference from the feeding habits of European hake that makes the paucity of deep-water observations during winter the more regrettable.[2] Although the distribution of *M. hubbsi* overlaps that of *Micromezistius australis* to the southward, the latter was not recorded as a constituent of the hake food. This is extraordinary because *M. australis* is very closely related to our own blue whiting *M. poutassou* (Norman, 1937, p. 51), which Hickling (1927, p. 42) had shown to be such an important constituent of the food of European hake. It seems that *M. australis* keeps more exclusively to deeper water and higher latitudes than its European counterpart, and therefore its habitat—during the warmer months of the year—does not coincide with that of the hake to anything like the same extent. In winter the southern blue whiting may move northwards as well as offshore, as will be shown in the section dealing with that species. Possibly the hake then feed upon them as we should have expected; but the fact remains that there was no evidence of this at the few stations where we did locate the two species together.

It will be noted that the list of food organisms includes several bottom-living fishes and a little benthos. The slightly more benthic tendency in choice of food is doubtless occasioned by the uniformly

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[1] References to this phenomenon in Quinat salmon (Jordan), silver eels (Petersen) and pleuronectids (Todd), are quoted by Hickling (1927), and he was further able 'to suggest that the blue whiting (*Micromezistius poutassou*) also feeds much less as its spawning time approaches'. Similar behaviour among Labrador cod would seem to be implied by Harold Thompson (1943, p. 84). He says they 'depend upon caplin for the period of gross feeding and recuperation which succeeds the spawning season'.

[2] I must reiterate that this was due to the precipitous slope preventing trawling, and not to any lack of endeavour.

moderate depths of the Patagonian shelf, which gives a much slighter depth gradient than the habitat of the better known species, until the edge is reached. The few echinoderms, etc., were, moreover, recorded in autumn, when the fish feed ravenously upon whatever comes their way.

Table 27. *Feeding of* Merluccius hubbsi

Food categories	Times recorded and percentage occurrence (italics)					
	Third survey (summer)		First survey (autumn)		Second survey (winter)	
Clupea fuegensis	12	*26·1*	19	*16·5*	34	*28·1*
Merluccius hubbsi	2	*4·3*		—	1	*0·8*
Macruronus magellanicus	1	*2·2*	—	—		
Salilota australis		—	1	*0·9*		—
Notothenia ramsayi	—	—	3	*2·6*	6	*5·0*
Notothenia spp.	7	*15·2*	2	*1·7*	5	*4·1*
Stromateus maculatus	2	*4·3*	2	*1·7*		—
Thysanopsetta naresi	—	—	7	*6·1*		—
Unidentified fish	1	*2·2*	8	*7·0*	9	*7·4*
Post-larval fish	—	—	1	*0·9*		—
Total fish	25	*54·2*	43	*37·4*	55	*45·4*
Large squid	—	—	7	*6·1*		—
Squid	10	*21·7*	14	*12·2*	4	*3·3*
Total squid	10	*21·7*	21	*18·3*	4	*3·3*
Decapoda	—	—	—	—	2	*1·7*
Munida subrugosa	6	*13·0*	—	—	—	—
M. gregaria	1	*2·2*			—	—
Munida unidentified	3	*6·5*	7	*6·1*		—
Euphausians	—	—	13	*11·3*	56	*46·3*
Parathemisto gaudichaudii	1	*2·2*	1	*0·9*	2	*1·7*
Hyperid amphipods*	—	—	18	*15·7*		—
Amphipods		—	4	*3·5*		—
Serolis sp.	—	—	2	*1·7*	—	—
Total Crustacea	11	*23·9*	45	*39·2*	60	*49·7*
Holothurians	—	—	1	*0·9*		—
Asteroids	—	—	1	*0·9*	—	—
Ophiuroids	—	—	2	*1·7*	2	*1·7*
Sponge fragments	—	—	2	*1·7*		—
Total echinoderms, etc.	—	—	6	*5·2*	2	*1·7*
Total separate records	46	*99·8*	115	*100·1*	121	*100·1*

* Doubtless mainly *Parathemisto*.

Hints of some interesting seasonal changes in dietary may be gathered from Table 27, although the data are not quantitative. Squids were obviously an important food in summer and especially in autumn, but were rarely recorded in winter-caught hake. Of the crustacean constituents, chiefly important to the smaller hake, *Munida* were eaten largely in summer, when there were no records of euphausians in the stomachs. In autumn there was still some *Munida*, considerable quantities of euphausians and many hyperid amphipods. (There is little doubt that nearly all of these were *Parathemisto gaudichaudii*, a very common species over most of the southern ocean, but I give the categories as stated in the original records.) In winter euphausians were the most frequently recorded food, and few other Crustacea were present. It is probably significant that the widest variety of food was recorded in autumn, when the hake were feeding intensively after spawning.

The relative importance of the different constituents of the food of *Merluccius hubbsi* cannot be accurately gauged without weight or volume records and altogether more extensive data, but a system of arbitrary weighting (kept well on the 'safe side') permits a diagrammatic presentation of seasonal changes in the major (lumped) categories, that gives a useful general picture. It may be regarded as a cautious understatement of the predominance of fishes and cephalopods in the diet, and of the obviously great importance of *Clupea*, especially in winter. The 'weighting' employed, after due consideration of known weights of most of the food organisms was: regarding Crustacea and benthos as unity, cephalopod records were multiplied by four and fish records by five. The results are shown in Fig. 26. Doubtless this picture would be altered by more detailed results, especially if the size of the fish could be taken into account, but such work will only be possible when a naturalist can devote his whole time to the one problem.

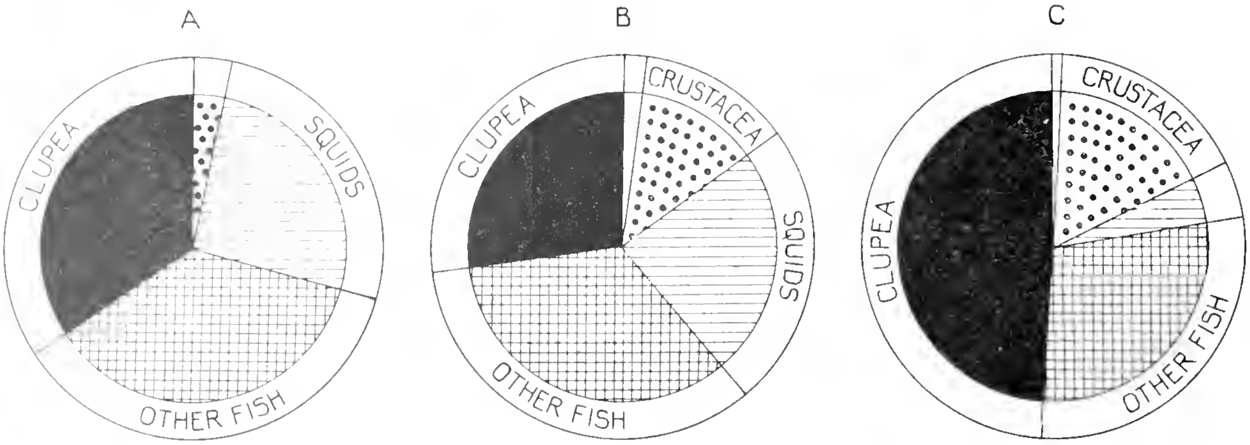

Fig. 26. Diagrams showing crude relative proportions (arbitrarily weighted) of the main food categories of *Merluccius hubbsi* at different seasons. Weighting: fish × 5, squids × 4, Crustacea × 1, and echinoderms, etc., × 1. Echinoderms, etc., which are rarely eaten are left white in the diagrams. A, third survey, summer. B, first survey, autumn. C, second survey, winter.

PARASITES

Like most other sea fishes *M. hubbsi* were observed to be very commonly infested with nematode, cestode and trematode worms. On the first survey these three classes of parasites were observed to be present in (roughly) the order of frequency in which they are named above, and it was noted that they seemed particularly abundant in the larger (older) fish. Almost all the specimens examined had nematodes in some part of the digestive tract or in the body cavity. Copepodan parasites were evidently less frequent but not uncommon. Chondracanthidae were more than once recorded as numerous in the mouth, and Miss N. G. Sproston informs me that members of this family frequently infest European hake also.

There are numerous references to *Lernea* and Lerneidae in the log-books, which introduce an unfortunate element of doubt into some carefully collected statistics of the incidence of this form of parasitism during the third survey, when the hake were sorted into length classes for weighing. I believe that these records all refer to a lernaeocerid either identical with our own *Lernaeocera branchialis* or very closely allied to it, but earlier references to '*Lernea*' on external situations (*L. branchialis* is strictly a blood-vascular parasite, and has been recorded from European hake) leaves some element of doubt. The situation is clouded by the unfortunate change of status of the genus *Lernea* so justly deplored by Gurney (1933, p. 336). To be quite safe, these parasites may all be referred to the family Lernaeoceridae as proposed by him.

The bulk of the figures were obtained in December, in the northern and intermediate regions, that is, in the most favourable part of our area for hake, at a time when the seasonal shoreward migration had begun. There is thus a good chance that the figures may be fairly representative, though the chances of infection by these parasites might vary with the seasons. A few data obtained farther south, at other times, do not suggest this, and in the main confirm the picture given by the good December figures. The latter only are considered here. The results are given in summarized form in Table 28, and the increase in percentage of female fish infected with increasing length is shown graphically in Fig. 27.

Table 28. *Incidence of infection by Lernaeoceridae,* Merluccius hubbsi, *north of 50° S, December* 1931

Length classes cm.	No. females examined	No. females infected	Females % infection	No. males examined	No. males infected	Males % infection
21–30	63	1	1·59	64	4	6·25
31–40	107	4	3·74	70	0	0
41–50	216	13	6·02	29	1	3·44
51–60	334	24	7·19	1	0	—
61–70	164	15	9·15	—	—	
71–80	37	8	21·62	—	—	—
81–90	1	0	—			—
	Σ 922	Σ65	*M* 7·05	Σ164	Σ5	*M* 3·05

It will be seen that female *Merluccius hubbsi* showed a steady increase of 'percentage infection' with these parasites as they grew longer (and older), and marked increase in the highest length group for which adequate figures are available. Females appear to be more than twice as often infected as are males.

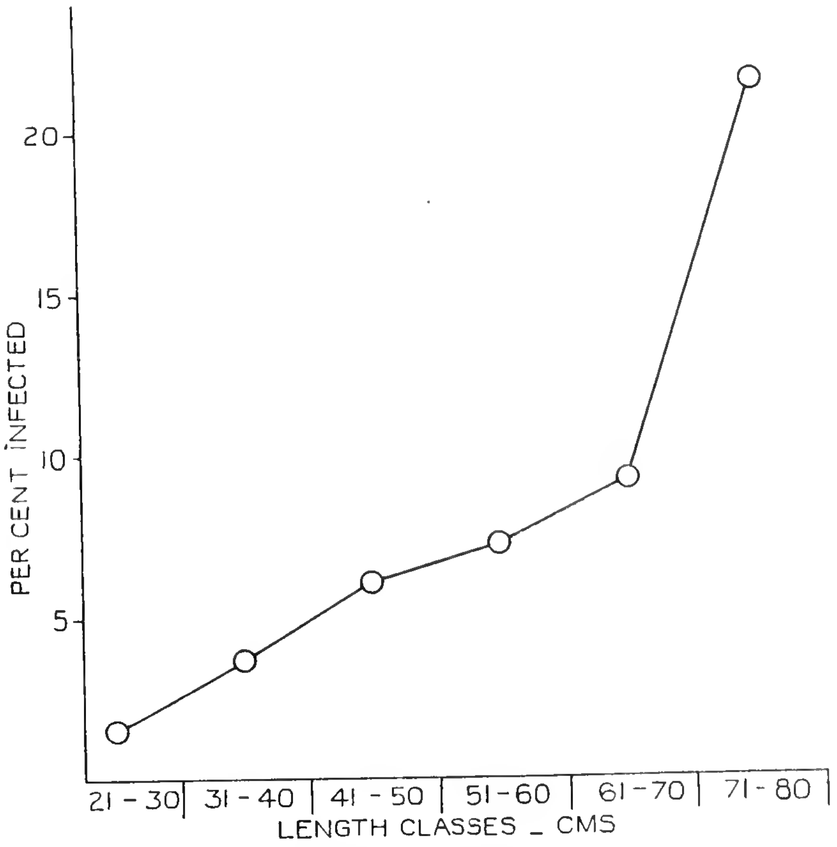

Fig. 27. Increase in infection by Lernaeoceridae with increase in length (and age) of female *Merluccius hubbsi*.

The males do not show any correlation between increase in length and increase in liability to infection. The smallest length class showed the highest percentage infection, which was also considerably higher than that of females of the same length. I think this discrepancy is in some way bound up with the marked differences between the sexes that became apparent in the study of the general bionomics of this fish. Apart from the size difference, and almost certainly slower *later* growth rate, male *M. hubbsi* reach maturity at a much smaller length than females, they seem less given to shoaling during the 'off' season, and do not migrate so far as the older females. All these factors may influence their chances of infection by Lernaeoceridae.

Macruronus magellanicus Lönnberg

This is a long, slender fish, with close superficial resemblances to the Macruridae, with which it was formerly classified. Norman (1937, p. 49) has shown, on osteological grounds, that it should be placed in the family Merlucciidae. The tail, tapering to a point and without a separate caudal fin, is the most noticeable point of similarity to the macrurids, but *Macruronus* lacks their projecting snout, and its distribution and habits are markedly different. *Macruronus* is found in numbers only on the shelf, in relatively shallow water during at least nine months of the year, whereas the macrurids are essentially a deep-water group inhabiting the slope beyond the shelf edge and even greater depths. The coloration of *Macruronus* reflects this difference in habitat. In Plate XVI a water-colour sketch of a living specimen taken at St. WS 99, by E. R. Gunther, is reproduced. At an earlier station he had described its coloration thus: 'laterally a pale lustrous blue, becoming more intense dorsally into tones of sapphire and turquoise, ventrally losing colour becoming silvery white.' A colour pattern such as this is normally characteristic of mid-water fishes inhabiting moderate depths over a well-illuminated sandy bottom, and this would apply fairly to that part of the plain of the shelf where we found the smaller individuals most abundant.

It is interesting to note that the correct taxonomic position of *Macruronus* is reflected in the local Spanish-American name 'Merluza de cola' which Norman (loc. cit.) states is applied to it. This might be freely translated into 'long-tailed hake' with advantage, for English-speaking fishermen tend to apply the names 'rat-fish' or 'rat-tail' to anything remotely resembling a macrurid, consequently confusing them with fishes as genetically remote as chimaerids in some parts of the world.

M. magellanicus is the second most important fish of the Patagonian Continental Shelf. In our catches it was outnumbered only by *Notothenia ramsayi*, but although slightly more numerous than hake in the aggregate it was less widely distributed, a few exceptionally rich hauls augmenting the total unduly. A much more slender fish than the hake, it is about half as heavy at a given length, and a larger proportion of the smaller individuals escaped through our normal cod-end mesh. There are numerous references in our rough logs to '*Macruronus* seen escaping'. In the eighty-six summer hauls of the third survey, for which roughly comparable weight data are available, *Macruronus* yielded 29·5% by weight of the total fish taken (rubbish excluded) as against the 47·3% of hake. The relation to other less important categories can be seen from the tables in the concluding section of this report. *Macruronus* was the most important species in the southern region, where, as we have already seen, the hake diminished greatly in numbers. Of the weight of fish caught here, *Macruronus* provided 46½%.

M. magellanicus is most excellent eating. In the third (unpublished) scientific report on the work of the 'William Scoresby' Dr Mackintosh wrote: 'It is generally agreed that *Macruronus* is superior to any of the other common fishes. The flesh is reasonably firm and free from too many small bones.'

Our records of the total catch of this species are as follows:

WS77	12. iii. 27	1	**WS790A**	14. xii. 31	107	*WS814*	13. i. 32	981
WS79	13. iii. 27	4	**WS790B**	14. xii. 31	23	*WS815*	13. i. 32	2
WS91	7. iv. 27	3	**WS791B**	14. xii. 31	30	*WS816*	14. i. 32	56
WS92	8. iv. 27	24	**WS792A**	15. xii. 31	9	*WS817A*	14. i. 32	5
WS94	16. iv. 27	49	**WS792B**	15. xii. 31	932	*WS817B*	14. i. 32	2
WS95	17. iv. 27	2	**WS793**	15/16. xii. 31	5	*WS818A*	17. i. 32	2
WS99	19. iv. 27	4	WS796A	19. xii. 31	56	*WS818B*	17. i. 32	1
WS108	25. iv. 27	32	WS796B	21. xii. 31	3	*WS838*	5. ii. 32	33
WS216	1. vi. 28	1	WS797B	20. xii. 31	26	*WS848*	10. ii. 32	3
WS218	2. vi. 28	3	WS797C	20. xii. 31	37	**WS853**	21. iii. 32	26
WS762A	16. x. 31	1	WS799A	21. xii. 31	37	**WS855**	22. iii. 32	1
WS762B	16. x. 31	123	WS799B	21. xii. 31	12	WS857	23. iii. 32	48
WS763	16. x. 31	6	WS800B	22. xii. 31	1	**WS858**	24. iii. 32	5
WS764B	17. x. 31	4	*WS805*	6. i. 32	1	**WS859A**	25. iii. 32	12
WS765	17. x. 31	25	WS806	7. i. 32	1	**WS859B**	25. iii. 32	11
WS771	29. x. 31	12	WS807	7. i. 32	12	WS864	28. iii. 32	1
WS774	1. xi. 31	368	WS810	9. i. 32	3	*WS866*	29. iii. 32	1180
WS775	2. xi. 31	43	*WS811 I*	10. i. 32	162	*WS868*	30. iii. 32	98
WS776	3. xi. 31	162	*WS811 II*	12. i. 32	75	*WS870*	31. iii. 32	227
WS786	7. xii. 31	34	*WS812 I*	10. i. 32	33	*WS874*	3. iv. 32	11
WS788	13. xii. 31	1	*WS812 II*	12. i. 32	5	*WS875*	3. iv. 32	78
WS789	13. xii. 31	1	*WS813*	13. i. 32	80			

Two main features of the distribution already mentioned become quite clear from these figures: the greater relative abundance of the species in the southern region, and the tendency to form dense local shoals, so that a small minority of the catches are vastly bigger than the others. This latter feature is the probable reason for lack of a clear north to south gradient in abundance of *Macruronus* in our records. A single extra large catch (of small immature individuals) was made in the northern region, but no corresponding shoal happened to be encountered while we were sampling the intermediate region. It is clearly necessary to consider other lines of evidence, bearing on the probable spawning time and movements of the fish, that may help to explain the observed distribution. The most fruitful studies possible from existing data appeared to be considerations of seasonal variations in ponderal index, regional variation in mean length, and relation of relative abundance and mean length with depth; but before we pass on to these one most important feature, quite clear from the catch records, must be emphasized: *Macruronus* was present at only two stations worked in winter, and these were among the most northerly of thirty more or less comparable hauls worked along the shelf edge, and over the shelf, in the main summer haunts of the species. This strongly suggests that the fish move north in winter. The repeated attempts made by Mr John to trawl in deep water over the shelf edge during the winter survey sufficed to show the offshore movement of hake at that season, and should also have revealed the presence of *Macruronus* offshore if there were not also a considerable meridional component in the direction of movement of the latter species. We have no proof, of course, that *Macruronus* does not move eastwards offshore—it probably does, though not to the same extent as the hake—but it seems certain that it moves north as well, whereas any meridional component in the direction of movement of the hake would seem to be too small to be demonstrable from existing data.

In Table 29 the data have been grouped at mean dates, from stations selected according to their time distribution, so as to show the seasonal variation in 'average' ponderal index of *Macruronus* in each of the three regions. The chief stress was laid upon inclusion of stations within a narrow interval of time about the mean date and therefore regional differences in the other features shown—relative abundance, mean lengths and sex ratios from the same groups of data—are not fully illustrated by this array. The data suffice to indicate three main points, however: greater abundance and size of individuals in the south, and the constancy of the sex ratios, showing a slight preponderance of females in nearly all groupings. The seasonal variation in ponderal index shows a rise in all three regions from spring and summer to autumn. These results are also shown graphically in Fig. 28.

Table 29. *Data selected over short-time intervals in each region, to show the increase in ponderal index of* Macruronus magellanicus *during the season, with corresponding figures showing relative abundance, mean lengths and sex ratios, and the mean sex ratio for each region*

Mean date	Total *Macruronus*	Hours positive hauls	Fish per hour's + haul	Sex ratio % males	Mean length cm.	Average K	Sex ratio mean for region
			Northern region				
23. x. 31	37	2	18	41·7	41·7	0·290	40·8 % ♂♂
15. xii. 31	1089	15	73	40·0	37·6	0·312	
23. iii. 32	45	3	15	60·0	33·8	0·354	
			Intermediate region				
2. xi. 31	570	3	190	39·9	38·9	0·270	41·9 % ♂♂
20. xii. 31	153	15	10	49·0	37·6	0·345	
23. iii. 32	48	1	48	43·8	40·6	0·358	
			Southern region				
16. i. 32	1321	24	55	45·8	47·1	0·311	42·1 % ♂♂
8. ii. 32	36	2	18	44·4	55·9	0·322	
2. iv. 32	1212	5	242	38·0	49·0	0·343	

The figures for 'average' K are means of means. The fish were weighed in length groups, their individual lengths being known, but of course the numbers included in the weighings differed widely. Little difference between ponderal index of males and of females could be detected. The averaging of the K values obtained within the time limits stated is an attempt to obtain a general indication of the direction or trend of the seasonal variation, although the figures have no precise significance. The fact that they indicate a rise in ponderal index in each of the three latitudinal regions over the period studied seems, however, strongly significant in the general sense, though not demonstrable mathematically. The implication is that *Macruronus* spawns in spring.

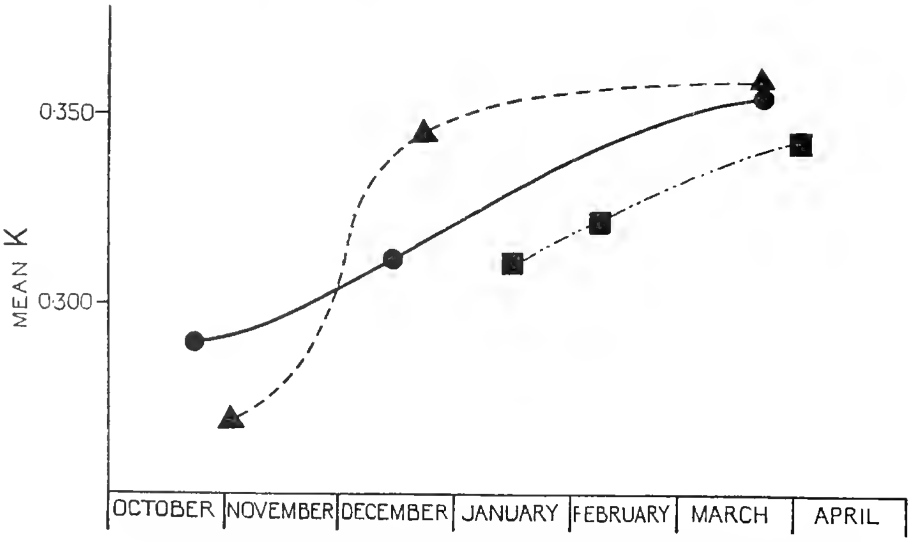

Fig. 28. Seasonal variation in mean ponderal index of *Macruronus magellanicus*: ● northern region, ■ southern region, ▲ intermediate region.

We have seen that in summer the fish is most numerous in the southern region, from which it was absent in winter. Thus the direction of movement in spring and summer must include a considerable

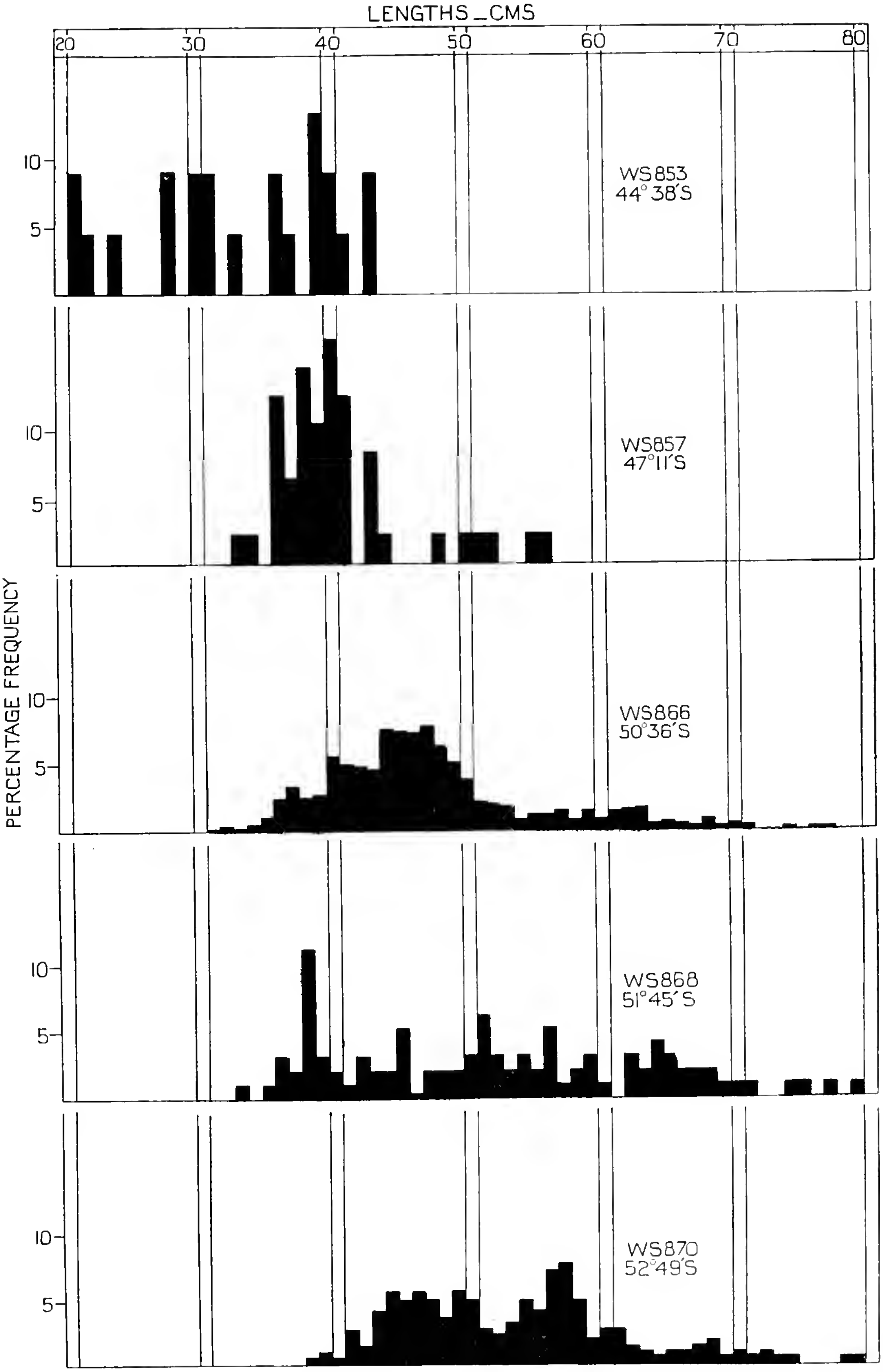

Fig. 29. Percentage length frequencies of *Macruronus magellanicus* at stations worked in long. 64° 15′ W, between 21 and 31. iii. 32, showing increase in length with increasing latitude.

southerly component. Further, it is highly probable that *Macruronus* spawns in spring, for the ponderal index rises during the summer. Many fishes feed most heavily just after spawning and it would seem that the movements of *Macruronus* during summer are essentially a feeding migration. The search for food may be expected to lead to considerable dispersion, and to local concentration where food is plentiful. This would help to explain the greater variation in size of *Macruronus* catches when compared with the catches of hake, whose summer movements are more in the nature of a breeding migration. At two of the large southern hauls of *Macruronus* the fish were observed to be glutted with clupeoids—probably the most important food of the larger individuals—and I think it probable that the southern concentrations of *Macruronus* and *Clupea fuegensis* will be found to coincide in summer.

Small immature individuals of *Macruronus* were found mainly to the north of our area, in comparatively shallow water. The southward movement in summer seems mainly confined to the larger mature individuals. Although a clear gradient in relative abundance and increasing size of individuals cannot be shown in lumped data as we proceed southwards from the northern region through the intermediate region, the greater abundance and size of individuals of the southern region population is clear however the data are arrayed. Over a short-time interval in March, the length frequencies clearly show the increase of size with increase of latitude (Fig. 29), and there is little doubt that this would have been apparent at other times had it been practicable to work more north and south lines.

The distribution of *Macruronus* in relation to depth has been found to have an important bearing upon the problems of its movements. The depth relations from all data, regardless of region, are shown in Table 30, where the catches have been grouped in 50 m. depth classes. From this it is at once apparent that it is very much an inhabitant of the plain of the shelf, showing a marked falling off in relative abundance at depths greater than 150 m. It was never taken below 300 m. and, as can be seen by comparing the individual depths given in the Appendices with the catch records already listed, nearly all the deeper records were obtained in autumn. This may imply some offshore movement superimposed upon the meridional movement of which evidence has already been given.

Table 30. *Data summarizing the depth relations of* Macruronus magellanicus

Depth grouping m.	No. of hauls	Hours trawling	Total *Macruronus*	Hauls present	% occurrence	Fish per hour	Sex ratio % males	No. measured (= N)	Mean length cm.	σ mean length	σ^2_{3n}/N
1-50	3	$2\frac{1}{2}$	0	—	—	—	—	—	—	—	—
51-100	33	48	606	15	45·5	13	44·7	598	40·1	15·2759	0·3909
101-150	80	98	4271	38	47·5	43	41·3	3907	42·8	8·4497	0·0183
151-200	24	24	140	5	20·8	6	44·9	139	53·5	11·8251	1·0060
201-250	15	15	84	3	20·0	6	36·3	84	53·7	10·9372	1·4241
Over 251	14	21	232	4	28·6	11	33·9	232	53·3	8·8461	0·3373

The depth distribution is particularly interesting in relation to the mean lengths. In each of the three deeper depth categories in which *Macruronus* was found these slightly exceeded 53 cm., and no significance attaches to the slight differences between them. But in slightly shallower water, where the vast majority of our specimens were secured, the fish were much smaller, of mean length 42·8 cm., the difference from the means for all three deeper groupings being strongly significant. In the next shallower depth category there was a marked falling off in relative abundance and the fish were even smaller. Their mean length was 40·1 cm., and the further small decrease of 2·7 cm. in mean length is statistically significant. These data show that larger, mainly mature, fish preponderate in the smaller catches of *Macruronus* from the greater depths in which the species was found, while smaller mainly immature fish predominate in shallower waters. We have already seen that the smaller fish tend to be commoner to the north, so that it would seem that we have here another instance of the influence of size of fish upon movement. The larger fishes seem to range farther afield than the smaller ones. This is in good agreement with our unavoidably scanty observations upon the feeding habits of *Macruronus*, presently to be described.

Numerous computations of mean lengths of *Macruronus* have been made besides those tabulated here. From these it appears that the differences in size between the sexes is small. Females are usually larger by 1–2·7 cm. in mean length than males, but the difference can only be shown to be significant in large samples. The fairly constant sex ratios, with slightly fewer males in the deeper catches, and the general slight preponderance of females in the trawl, suggest (*a*) that the slightly smaller males may tend to migrate a little less than the females, (*b*) that the sex ratio is probably nearly normal near the main locus of the species, the discrepancy being due to a higher escape ratio of the smaller males. We have already seen how the much greater difference in size between the sexes seems to affect the distribution of the hake population.

Detailed notes upon the food of *M. magellanicus* were made at eight stations only. At four of these the fishes were small, the mean lengths being 34·4, 34·9, 35·0 and 44·5 cm. These fish were almost entirely carcinophagous and had been feeding heavily upon euphausians and *Parathemisto*; one was crammed with fish larvae, and a single specimen had taken a *Munida*. The other four records are from stations where the fish were considerably larger, of mean lengths 50·4, 51·8, 52·5 and 55·6 cm. These had been feeding exclusively and heavily upon *Clupea fuegensis* and *Notothenia* spp. (most being undoubtedly *N. ramsayi*). Squid have not yet been observed in the stomachs of *Macruronus*. It is therefore probable that *Macruronus* exhibits, perhaps to a marked degree, that change over from a carcinophagous to a fish diet that seems characteristic of many demersal fishes as they grow older (e.g. hake). The point should not be stressed unduly in the absence of data as to possible seasonal changes in diet.

The facts that only the larger fishes were found to be ichthyophagous in summer, and that they appear to migrate much more extensively than the smaller fishes, seem to find a close parallel in some of Harold Thompson's observations on Newfoundland cod (1943, p. 86). He says: 'It is seen that the volume [of food] increases rapidly with the size of cod, and it is probably this need for large quantities of food (unobtainable all the year round in any one locality) which leads to cod making increasingly great migrations as it becomes older; whereas small cod apparently find it possible, within a limited inshore area for example, to find sustenance in the smaller crustacean species for the first few years of their lives.'

There is further evidence that the age at which *M. magellanicus* attain a length of some 50 cm. marks a critical period in their lives, in the relation between length and ponderal index. Among females from the southern region values for *K* were highest among fishes of the 41–50 cm. length class (weighted mean $K=0·352$). Fish of the 51–60 cm. class gave values some 4% lower (weighted mean $K=0·340$) and two higher length classes gave lower values. If we had sufficient information to plot a curve for this relationship it seems fairly certain that the point of inflexion would lie at around 50 cm. The fall was slight because the reliable data were collected in March, and this is too long after the spawning period to give the best demonstration of this phenomenon. Earlier data are roughly in agreement, but inadequate to show the effect within convincingly narrow limits of time and space. The implication is that it is at a length of about 50 cm. that sexual maturity is first attained.

Thus it seems possible that sexual maturity, increased migratory movement (in search of food) and a change in the nature of the diet, follow closely upon one another in that year when the fish reach a length of some 50 cm.[1]

[1] *Possibly* their sixth year of life.

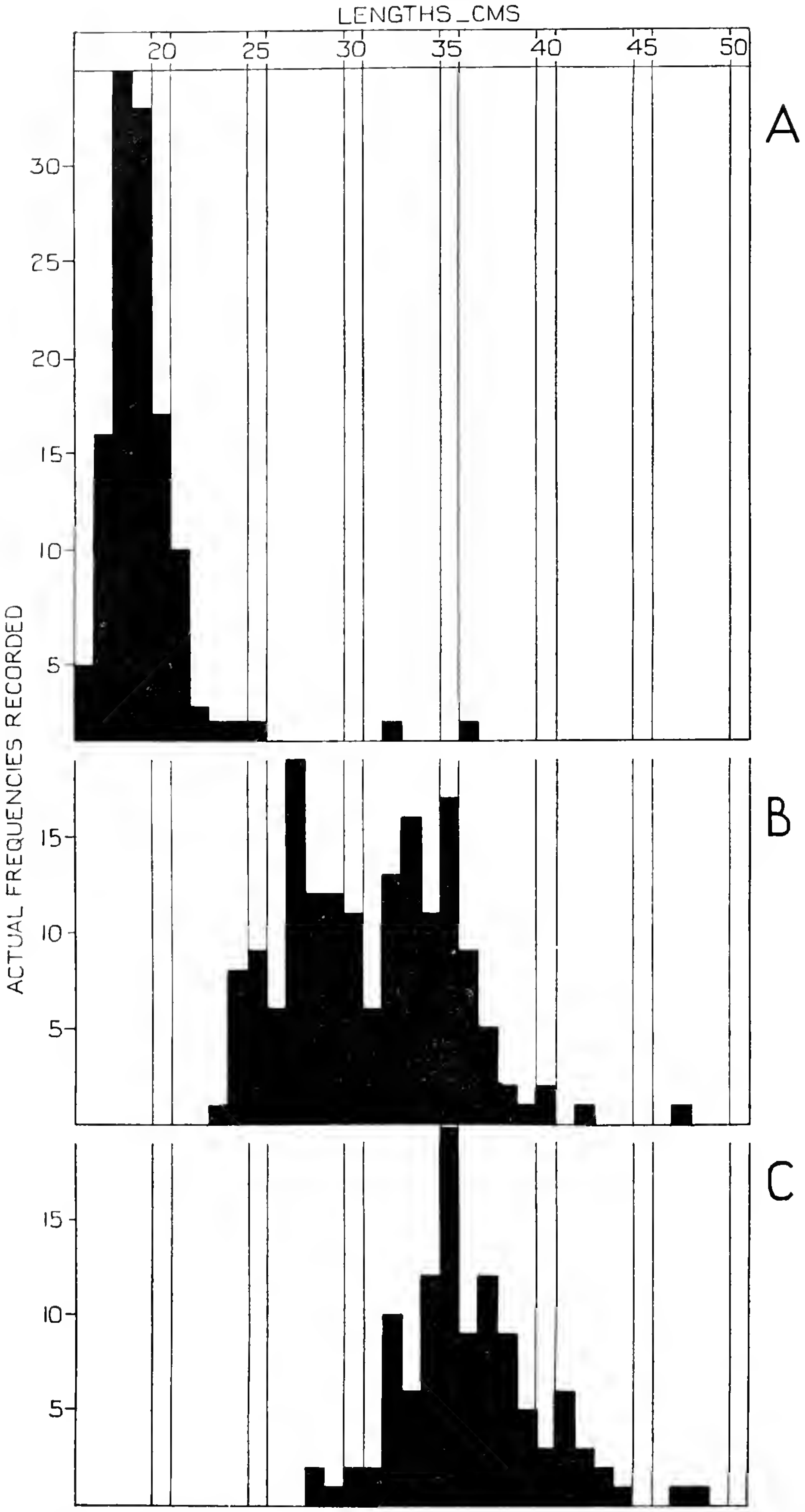

Fig. 30. Actual length frequencies of *Macruronus magellanicus* at selected stations, including probable year-classes at about 18, 27 and 35 cm. A, St. WS 762 A + B, 16. x. 31; B, St. WS 776, 3. xi. 31, and C, St. WS 790 A, 14. xii. 31.

Several series of length frequencies of *Macruronus* showed strong and moderately consistent indications of year classes, but the wide dispersion of our data in time as well as in space preclude any useful pooling of these results. As Petersen found long ago it was the younger fishes that tended to show this feature best. A few unmanipulated frequencies from stations worked early in the season, in the northern region, are shown in Fig. 30. These indicate possible year classes at 18–19 cm. (probably just two years old) at 27 cm. and at 35 cm. (? three and four years old respectively) while the third confirms the probable existence of a year class 35 cm. or so in length at that season. Later results suggest that growth is most rapid in summer, and that the yearly increments diminish so that fish of over 70 cm. may only grow some 5 cm. in the course of a year, but the data are insufficient to be conclusive.

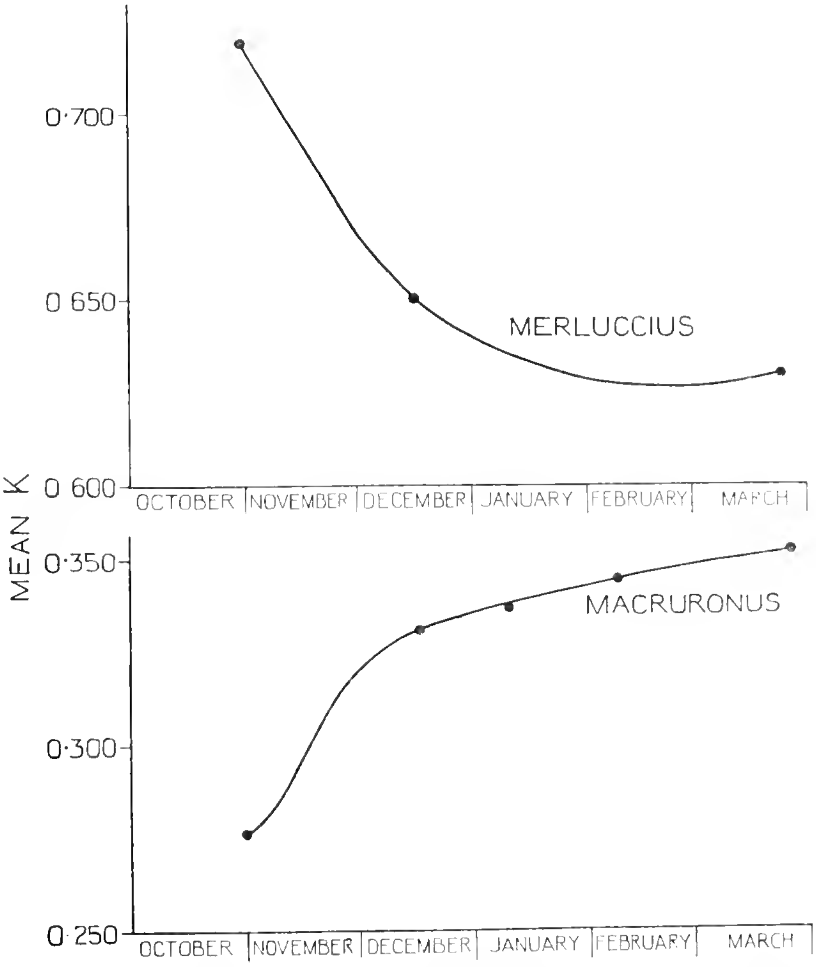

Fig. 31. Seasonal variation in ponderal index of *Merluccius*, a summer spawner, and of *Macruronus*, which would seem to spawn in spring.

Norman (1937, p. 50) has already pointed out the extremely close relationship between *M. magellanicus* (Lönnberg) and *M. novae-zelandiae* (Hector) from Tasmania and New Zealand, with which it was at first identified. This affinity extends beyond morphological features to coloration and habits. From Waite (1911, pp. 180–1) we learn that *M. novae-zelandiae* attains much the same sizes as the Patagonian species, that its colour may be described as a deep iridescent purple with the fins smokey and the lower parts silvery, and that it has been observed to feed upon *Clupea neopilchardus*. During the New Zealand trawling experiments of which Waite was writing several considerable catches of the species were made, all between 16 and 28 fm., and it was not observed in deeper water.

Reference was made to Dr Albert Günther's opinion (1887, p. 157) that 'it is not probable that it descends to the same great depths as the other *Macruri*', and to several strandings of the species in Cook Straits, which have also been referred to by other New Zealand writers. It is interesting to find that the essentially shoal-water habitat of the genus was recognized so early, in the days when it was still classed with the macrurids.

At the time of which Waite was writing it was thought that *M. novae-zelandiae* would be unmarketable in New Zealand, and I have not found any recent reference to its being utilized. It is evident, however, that New Zealanders suffer less from traditional inhibitions as to what constitutes a good food fish than some older communities, for we learn from Phillipps (1921) that *Coelorhynchus australis*, occasionally trawled in deep water in Golden Bay, is highly esteemed under the name of 'javelin-fish', and that large *Callorhynchus* sell well in Christchurch as 'silver trumpeter'. The nearest equivalents of both these species would certainly be discarded as rubbish by British trawlers. Since we found the Patagonian species of *Macruronus* most excellent eating I therefore venture to suggest that an attempt to market the New Zealand one might prove well worth while.

By way of summarizing our findings as to the bionomics of *M. magellanicus*, it seems both interesting and profitable to compare and contrast it with its near ally, the Patagonian hake:

Comparison and contrast of the main features in the bionomics of Merluccius hubbsi *and* Macruronus magellanicus

	Merluccius hubbsi	*Macruronus magellanicus*
Spawning season	Summer	Almost certainly spring
Extreme range of *K* and seasonal variation	From about 0·540 to 0·830. Falls during summer (see Fig. 31)	From about 0·250 to 0·390. Rises during summer (see Fig. 31)
Size difference between sexes	Males much smaller than females (difference 13·5 cm. between grand mean lengths)	Males only 1–2 cm. smaller than females, but the difference is nearly always significant in adequate samples
Depth relations	Vary with migration, but larger fish are found in deeper water except at the height of summer. Extended down to the greatest depths fished	The larger fish in deeper water but the species is mainly confined to the plain of the shelf. Not found in hauls exceeding 300 m. mean depth (we made seven such hauls, at four of which hake were present)
Size latitude relation	Mean lengths increased with latitude significantly except at height of summer	Mean lengths increased with latitude significantly whenever comparable data available
Migration	Strong inshore movement in summer, little north to south movement if any, offshore movement from autumn to winter	Considerable southward movement spring and summer. Some offshore movement in autumn? Northward movement in winter
Growth (speculative)	Perhaps similar to that of European hake, with length increments smaller in parallel with the smaller size of this species	Earlier length increments probably slightly greater than those of European hake, later ones diminishing sooner, more regularly, and markedly
Potentiality as human food	Flesh rather soft but not inferior to that of European hake of similar sizes	Flesh firmer and better flavoured, but less readily available as the fish are so much more slender

GADIDAE

Micromesistius australis Norman was discovered during the first of the surveys described here. Norman (1937, pp. 51–2) has pointed out its close relationship to *M. poutassou* of the Mediterranean and north-eastern Atlantic. So far as I have been able to determine, it is the only 'typical' gadid with three dorsal fins known to occur in south temperate and subpolar waters. At St. WS80, E. R.

Gunther noted its colour as 'slatey blue, darker above, a purer blue laterally, white ventrally'. Its general distribution in our catches (markedly southern and in deep water) is shown below:

WS80	154 m.	4	*WS817B*	220 m.	52	*WS825*	140 m.	2
WS99	238 m.	10	*WS818A*	275 m.	52	*WS839*	418 m.	1
WS216	176 m.	1	*WS818B*	281 m.	222	*WS840*	415 m.	5
WS217	146 m.	1	*WS819A*	320 m.	27	*WS850*	161 m.	12
WS218	279 m.	1	*WS819B*	335 m.	72	*WS868*	164 m.	7
WS816	150 m.	1	*WS820*	359 m.	22	*WS870*	272 m.	1
WS817A	196 m.	58	*WS821*	464 m.	1	*WS875*	243 m.	5

We have already had occasion to note that *Micromesistius australis* seems to inhabit higher latitudes (for the most part) than its European relative. We never found *Merluccius hubbsi* to have been feeding upon it, although as a result of Hickling's work it has long been known that *Micromesistius poutassou* is one of the most important forage species for the larger European hake. The two European species overlap almost throughout their latitudinal range, while off Patagonia *Micromesistius* occurs mainly to the south of the range of all but a very few of the hake.

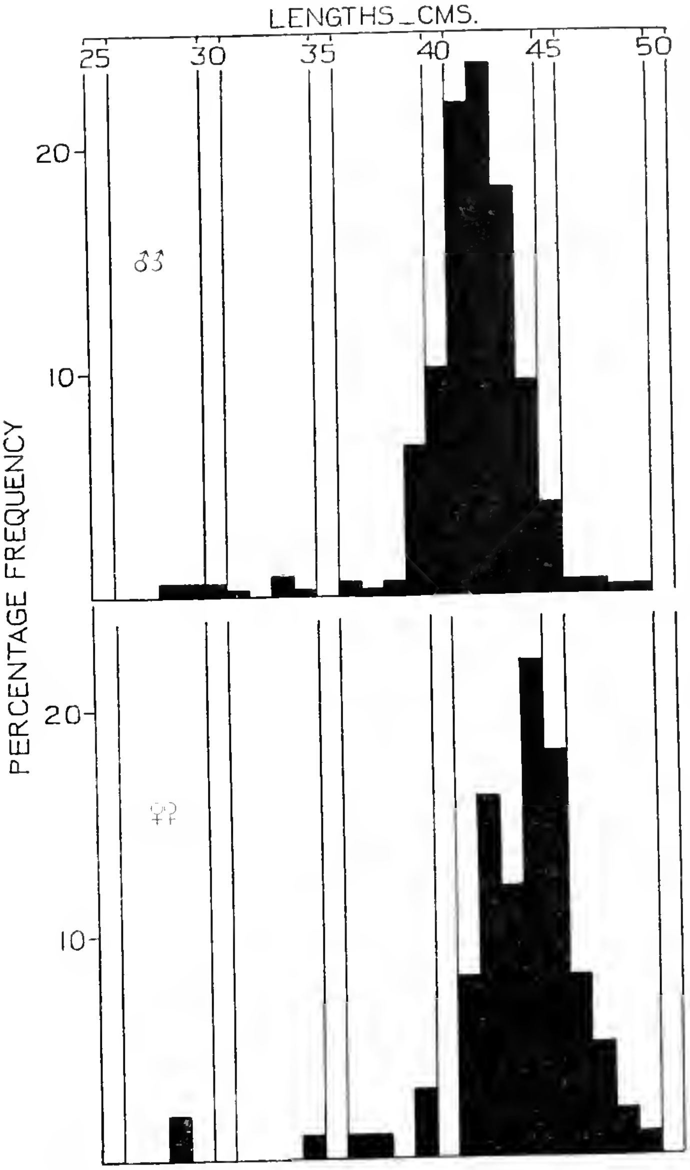

Fig. 32. Percentage length frequencies of *Micromesistius australis*, January 1932.

It can be seen above that all our specimens of *M. australis*—excepting one haul of 10 in 49° 42′ S and three singletons farther north in autumn and winter—were obtained in the southern region south of 50° S. It is also very clear that it is a deep-water species, very rarely to be taken on the shelf in numbers. All but one of our richer hauls were obtained in deep water beyond the shelf edge. It was present in all three of the deepest trawlings made, in depths of over 400 m.

A study of the length frequencies showed some remarkable features. All were very strongly unimodal and of very narrow dispersion. The pooled frequencies for the January stations, worked fairly close together in the southern region, over a brief period, are shown in Fig. 32. These data yielded mean lengths of 41·5 cm. ($\sigma = 2{\cdot}6257$) for males and 43·2 cm. ($\sigma = 3{\cdot}2392$) for females. The difference of 1·7 cm. is clearly significant. The slightly larger size of the females (a well-known feature in many diverse species of fish) might be expected to increase their chances of capture with the result of a slight 'spurious' preponderance of females in the catches. The sex ratio observed however was strikingly 'abnormal' in the unexpected direction—77% of the fish captured were males. This suggests the possibility of a tendency towards unisexual shoaling in this species during the non-breeding period. (The ponderal indices show a steady rise from January to April—suggesting spring or early summer spawning—but the data are inadequate for detailed consideration.)

The very narrow dispersion of the observed length frequencies (Fig. 32) shows that a majority of any modal class less than about 38 cm. long escaped through the normal cod-end mesh, as would be expected with such a small slender species. This was seen to occur and was duly recorded in the log-books. Above the very pronounced mode, however, such narrow dispersion (the biggest fish taken were only 49 cm. long) can only mean that little growth takes place after the fish have attained such modal length. The absence of all trace of a higher secondary mode shows that only a very small minority of the 41–43 cm. fish normally survive another year. It is possible, therefore, that *M. australis* is a short-lived fish of comparatively rapid growth. Fine-meshed trawlings to sample the smaller year classes would be essential to establish the point with certainty.

The food of *Micromesistius* was noted at two stations. It consisted of *Parathemisto* and Euphausians. In this respect, as in their deep-water habitat along the edge of the shelf, they resemble their European relative (cf. Hickling, 1927, pp. 53 et seq.). Hickling's findings also show that the European species spawns late in spring (in agreement with the season suggested as probable for the Patagonian species, from the seasonal shift in ponderal index) in the nearest corresponding latitudes. It is in the restricted distribution in colder waters than those frequented by the local hake that the Patagonian species shows the most striking difference from *Micromesistius poutasson*.

Salilota australis (Günther). Norman (1937, pp. 52–3) has explained how this genus is barely separable from the *Physiculus* of Kaup, with which our species was identified in the field. He has also a footnote concerning the circular, unscaled, pigmented area between the bases of the pelvic fins: 'This is associated with a luminous gland', and gives references to Hickling's work on the subject. From the latest of these (Hickling, 1931) it would seem that similar organs had long been known among a variety of Macruridae, and in *Physiculus japonicus* Hilgendorf alone among Gadidae. Hickling concluded that the gland is essentially a larval organ which may remain functional throughout life in some species (loc. cit., pp. 863–5). It functions strongly in the adults of *Malacocephalus laevis* (Lowe) (Hickling, 1925), but though functional in the young of *Coelorhynchus coelorhynchus* (Risso) it becomes vestigeal in the older fish. I have found a note of E. R. Gunther's stating that with *Salilota australis* luminescence was not observed in the field, so that it is possible that the gland is vestigeal (or less developed from its primitive condition in the common ancestral Anacanthini) in this species also. Gunther's first colour note (St. WS73) on the species reads: 'Evenly grey, slightly darker towards the back. Ventral surface slightly violaceous, becoming almost black at one spot anterior to the anus (this spot probably luminous). The scales suggest a faint brazen glitter.' It is therefore clear that our observers knew of the possibility of luminescence in this species from the first, but no such phenomenon was seen although numerous specimens both old and young were subsequently secured. The gland may very probably be functional in the larvae, but it would seem to be undeveloped or vestigeal in the older stages of *S. australis*.

Our records of this species, set out below, show that its seasonal and regional distribution resemble those of *Macruronus*. It is, however, much less numerous and more widely spread, which suggests that it is much less given to shoaling.

Salilota australis was also taken in seventeen hauls during the first autumnal survey. Only four of these were situated in the intermediate region; all the rest, including the four richest hauls of ten or more individuals, were in the southern region. St. WS99 provided the only record of the species in deep water over the edge of the shelf at this season.

During the second survey, made in winter, the species was taken in fifteen hauls. Of these one was in the northern region, eight were in the intermediate region and only six in the southern region. The species was recorded seven times in depths greater than 200 m., but four of these records refer to single individuals. There is here a strong suggestion of northward movement in winter, coupled perhaps with some offshore movement (mainly confined to the larger fish).

WS73	3	WS216	11	WS785A	3	*WS818A*	1
WS75	34	WS217	39	WS785B	3	*WS838*	3
WS78	1	**WS218**	8	**WS791B**	1	*WS847A*	1
WS79	10	WS219	3	**WS792A**	2	*WS848*	28
WS80	25	WS222	2	**WS792B**	7	*WS849*	3
WS81	3	*WS225*	1	WS794	3	**WS855**	2
WS83	2	WS234	1	WS799B	3	WS857	2
WS84	5	WS237	1	*WS803*	8	WS864	3
WS89	2	*WS239*	1	*WS804B*	1	*WS866*	15
WS90	32	*WS243*	1	*WS805*	2	*WS868*	30
WS92	2	*WS244*	1	WS810	57		
WS93	7	*WS245*	10	*WS811 II*	9	WS586	2 on LH
WS94	1	*WS250*	1	*WS812 I*	3	51	3 juv. in OTL
WS97	6	**WS764B**	2	*WS812 II*	7	WS863	2 in BTS
WS98	1	WS773	8	*WS813*	2	WS861	2 in BTS
WS99	4	WS774	1	*WS814*	12	*WS865*	6 in BTS
WS108	2	WS775	3	*WS815*	1	*WS867*	2 in BTS
WS213	1	WS776	1	*WS817A*	11		1 in NR
WS214	7	*WS781*	1	*WS817B*	15	*WS869*	1 in BTS

During the third survey, worked from late spring through summer and autumn, the species was recorded from thirty-five trawling stations: nineteen in the southern, eleven in the intermediate and five in the northern regions. There was only one northern record after midsummer, and only two records in deep water, both near the southern limits of the range of the species. One rich haul was made in the intermediate region, six others were all southern with a hint of increasing abundance in late summer and autumn. Southerly movement during summer seems fairly certain, and this evidently takes place over the plain of the shelf (cf. depths at the relevant stations, recorded in the Appendices).

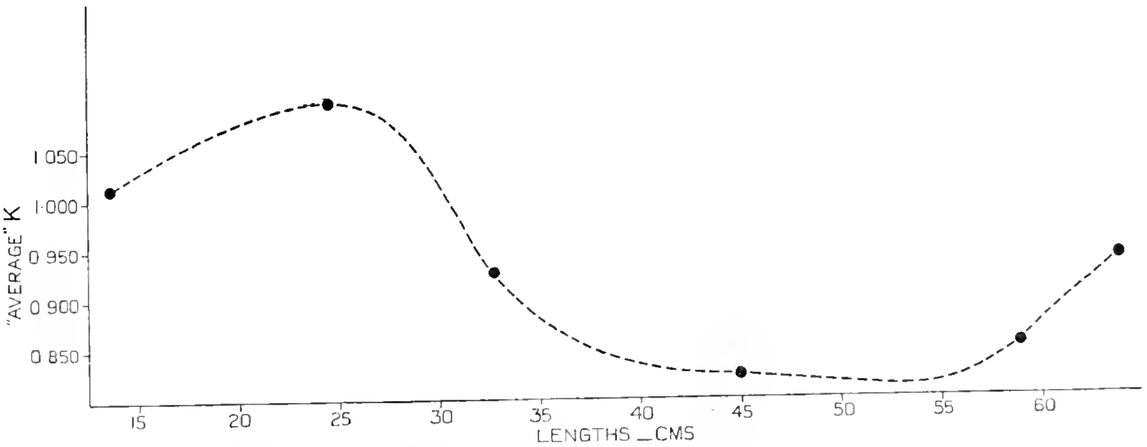

Fig. 33. 'Average' *K* of *Salilota australis* plotted against the true mean lengths in length groups, January 1932.

A general examination of length measurements showed that juvenile *S. australis* were nearly always found in shoal water, and near the northern limits of that part of the range of the species covered during any given period. There was a tendency for larger fish to be found in deeper water than smaller ones. The sex ratios appeared to be roughly normal, and females significantly larger than males, but our data are less complete than for more important species (there was not always time to sex *Salilota*) and are not given in full here.

The weight records are sufficient to yield evidence on two important points. The ponderal indices of *Salilota* in January, plotted against length, are shown in Fig. 33. The form of the curve (pecked line) joining the points has no real meaning. It is useful as a guide to the eye, and is a freehand approximation to the curve expected, judging by the way this relationship varies in other fishes for which we have better data. It is quite clear, however, that whatever curve were fitted it would show a point of inflexion between a length of 25 and 30 cm. It is therefore probable that these fish first attain sexual maturity at about that length.

The seasonal variation in ponderal index of *Salilota* more than 25 cm. long, for the period December to the end of March 1932, is shown in Fig. 34. This shows a steady rise, steeper latterly. We have just seen that most of these fishes are probably mature, so that we have here a strong suggestion that spawning takes place in late spring or early summer.

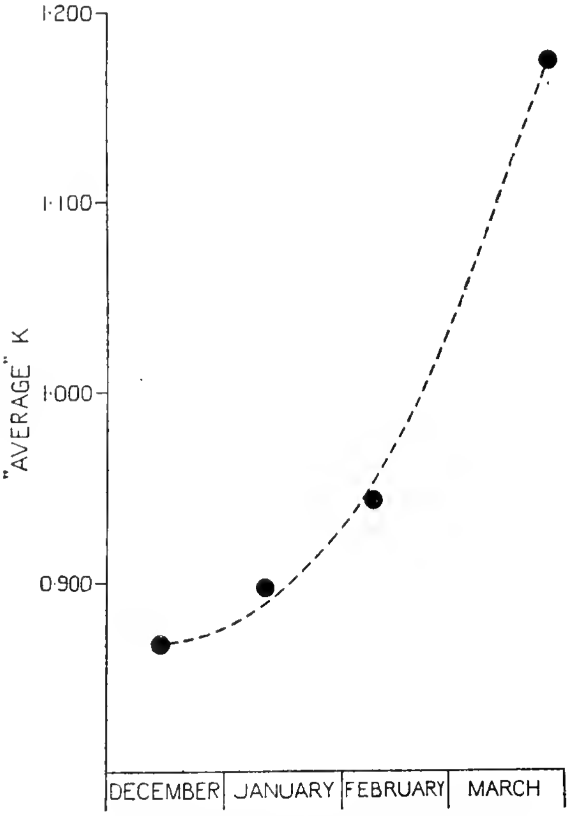

Fig. 34. Seasonal variation of ponderal index observed in *Salilota australis*, 1932.

Several series of length frequencies of this species gave strong modal indications of the younger year classes. The percentage frequencies of the pooled results, in the southern and intermediate regions, over stated periods, are shown in Fig. 35. The implications of these are fairly clear: the autumn results are most helpful, for we were then fortunate enough to capture sufficient of the young fry (about 5 cm. long) in the accessory nets attached to the back of the trawl, for these to appear as a mode of equal strength to that formed by the (presumably) I-group fish at 16 cm. This indicates a growth of some 11 cm. during the first year of life, and there is also just a hint of a possible submode at 26 cm. suggesting 10 cm. as the second annual increment. The main mode of the January figures, and of the winter (June–July) figures is clearly due to I-group fish as represented by the 16 cm. mode in autumn. It will be seen that the shift to the right of 6 cm. of the I-group mode between midsummer and midwinter is compatible with the growth-rate suggested above, for growth is usually more rapid during the second half of the year in fishes living in cold or temperate latitudes. In conjunction with the evidence afforded by the ponderal indices we may therefore say that *S. australis* is a fish of rapid growth, probably reaching maturity in the third year of its life. It may be well to state that rapid growth rates are known in other small Gadidae, notably in *Gadus merlangus* (Hartley, 1940, p. 48, where an even higher growth rate than that postulated for *Salilota* is explained by the absence of a winter fast in young fish frequenting estuaries).

No time could be spared for investigation of the feeding of *S. australis*. One was observed to have eaten large isopods, and it may be permissible to guess (from its colour pattern) that it is more of a bottom feeder than *Micromesistius*.

Physiculus marginatus (Günther). This small species was taken at the following trawling stations, all in our southern region:

WS75	18 of 5–7·3 cm.	WS820	1 of 16 cm.
WS817A	1 of 18 cm.	WS821A	2 of 16·3 and 17 cm.

Norman (1937, p. 54) gives 22·5 cm. as the length of the largest specimen known to him, and southern Chile and Magellan Straits as other known localities. As far as we know, therefore, the species is too small and too scarce to be of practical use to man.

MURAENOLEPIDAE

Muraenolepis microps Lönnberg. A single specimen of this Antarctic species, 19 cm. long, was taken on the Burdwood Bank at St. WS 82, in the extreme south of the area covered by the trawling surveys.

Muraenolepis orangiensis Vaillant. A single specimen, 19 cm. long, was taken at St. WS 825, near the edge of the shelf to the north-east of the Falkland Islands. It is also known from the Magellan Channels.

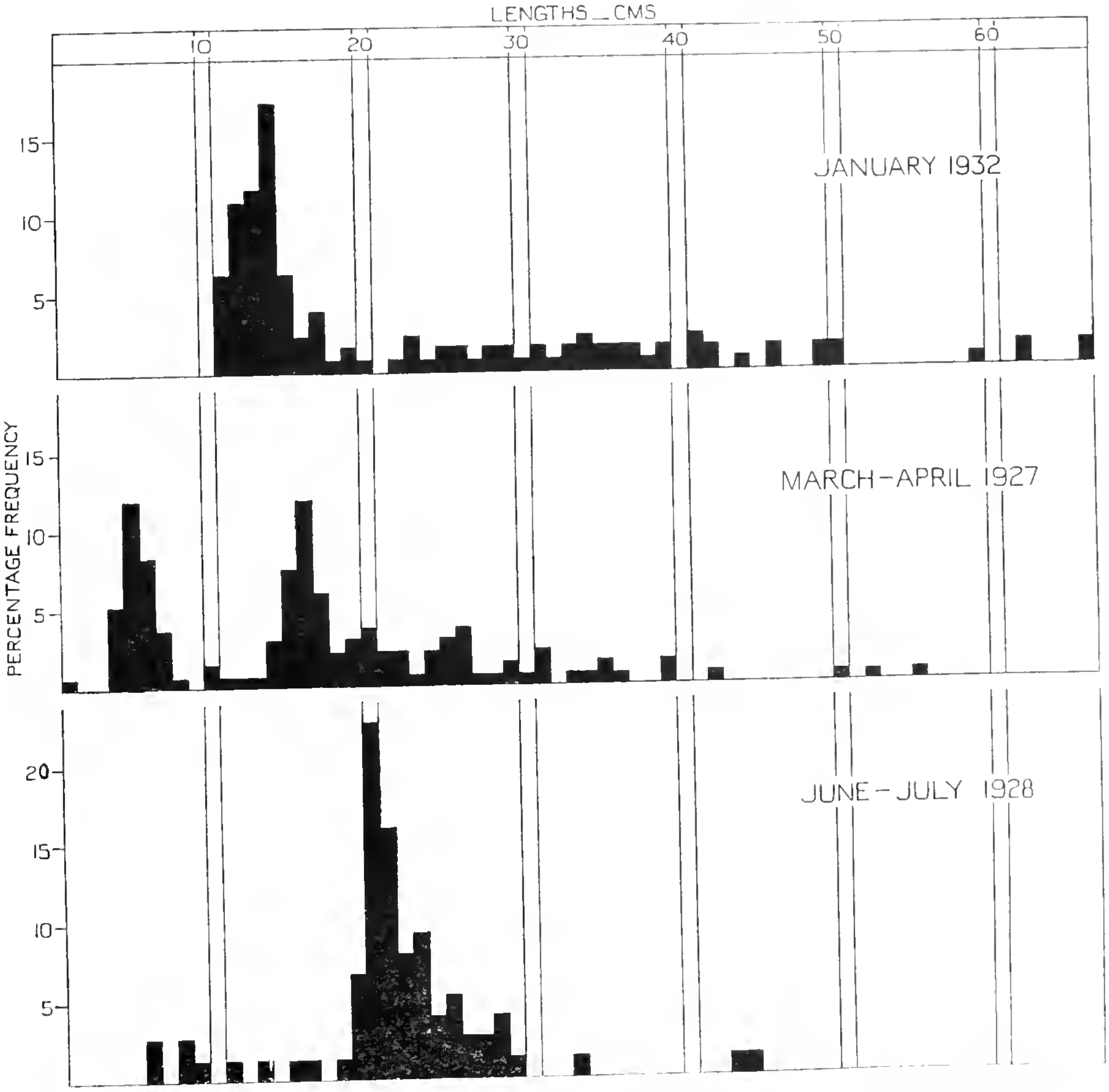

Fig. 35. *Salilota australis*. Percentage length frequencies, southern and intermediate regions, at stated periods.

CARANGIDAE

Parona signata Jenyns was taken by us only at St. WS 847, close inshore in the southern region, where we secured six specimens between 46·5 and 60 cm. in length. The list of localities given by Norman (1937, p. 60), southern Brazil, Uruguay, Buenos Aires, Rio Grande do Sul and Bahia Blanca, indicates that these were probably stragglers. The normal habitat of the species is probably to the north of our area.

BOVICHTHYIDAE

Cottoperca gobio (Günther). The range of this species extends to the west coast of southern Chile, outside our area (Norman, 1937, p. 64). Our records show that most of our specimens were captured in the southern region, though one rich haul was taken in the intermediate region at St. WS97. *Cottoperca* was captured in the northern region twice only:

WS71	41	WS221	1	WS814	1
WS73	3	*WS225*	5	*WS815*	2
WS77	2	WS237	2	*WS817*	3
WS79	5	*WS243*	23	*WS818A*	1
WS80	1	*WS244*	4	*WS837*	2
WS81	8	*WS245*	5	*WS847A*	3
WS83	57	*WS246*	22	*WS847B*	1
WS85	22	*WS247*	1	*WS848*	2
WS86	27	*WS248*	7	*WS849*	2
WS90	1	*WS781*	1	*WS850*	1
WS92	2	WS787	2	*WS851*	1
WS93	31	**WS792A**	1	*WS866*	1
WS94	4	WS795	1	*WS872*	1
WS95	13	WS797C	1	*WS874*	1
WS97	79	*WS803*	1	Port Stanley	3 with LH (A. G. B.)
WS98	1	*WS804A*	3	Puerto Acero	1 with LH
WS108	1	*WS804B*	8	WS583	3 in BTS
WS217	1	*WS805*	1	WS836	49 in BTS
WS218	2	WS809	2	WS867	1 in BTS

The depth records (Fig. 42) show that *Cottoperca* ranges from shallow coastal waters right out to the shelf edge and, rarely, beyond; but it is mainly an inhabitant of the plain of the shelf. There does not seem to be any definite migration over the shelf edge; although the fish showed some tendency to occur in deeper water in winter than at other times, this movement did not appear to be extensive.

The widespread occurrence of this species in small numbers leaves us with measurements that cannot usefully be pooled. The largest samples give a hint that the annual length increments over the main growing period are around 7 cm. Somewhat larger than most of the nototheniiform fishes of the area, *Cottoperca* commonly attains a length of some 35 cm. at a weight of about 500 g. Our largest specimen was 61 cm. long, and we had several over 40 cm. The larger fishes usually occurred in deeper water, but from our material the females could not be shown to be larger than males. They were in fact rather smaller, which is a most unusual feature. Our few rich hauls of *Cottoperca* were made in autumn, which suggests that schooling may take place at that season. The sex ratio appears to be normal. Weight records suggest that maximum condition coincides with maximum temperatures for the year in late summer. As maximum schooling seems to take place in autumn, this strengthens the suggestion that spawning may take place at that season.

Although edible and of better size than most members of the group in our area, *Cottoperca* is unfortunately the most tasteless and undesirable of the nototheniiformes (not a very palatable group) when used as human food.

The stomach contents of thirty individuals show that *Clupea* was the main food, but apart from these it seems that *Cottoperca gobio* is mainly a bottom feeder. The other recognizable constituents were: the small flatfish *Thysanopsetta maresii*, the Atelecyclid crab *Peltarion spinulosum*, and other Brachyura.

Bovichtus argentinus MacDonagh. We took no specimens of this apparently coastal species, but a young example from Puerto Madryn was given to Norman by Mr MacDonagh, and since the holotype came from the Golfo san Jorge it is evident that it occasionally penetrates southward to the area of the trawling surveys. Norman (1937, p. 65) points out that it may prove to be identical with *B. chilensis* Regan, from the west coast, when comparison of specimens of similar size is possible.

NOTOTHENIIDAE

Notothenia macrophthalma Norman. The holotype of this new species was trawled in deep water (368–463 m.) at St. *WS840*, near the Burdwood Bank. Norman (1937, p. 68) states that it is very closely related to *N. squamifrons* Günther, from Kerguelen. Unfortunately no other specimens have been secured.

Notothenia trigramma Regan. We did not capture any examples of this distinctive species, known only from the holotype from Port Stanley in the Bruce collection (Norman, 1937, p. 69).

Notothenia canina Smitt. This small coastal species showed a very restricted distribution in our catches, being taken only near the eastern entrance to the Magellan Straits, and in Grande Bay. All the records come within our southern region, and it is noteworthy that the types also are from Puerto Gallegos in Grande Bay (Norman, 1937, p. 70). Norman also states that some specimens from Tierra del Fuego, undoubtedly referable to this species, were wrongly attributed to *N. acuta* Günther by Steindachner. Our records of *N. canina* are:

WS89	2	*WS834*	8	*WS847A*	1	*WS835*	45 (BTS)
WS833	18	*WS837*	1	*WS812*	7	*WS836*	4 (BTS)

All but the first of these were obtained in late summer, so that it is perhaps permissible to take some note of the pooled measurements. The species is a small one, these scanty data showing a mean length of 10·1 cm. with $\sigma_M^2/N = 0{\cdot}1099$. A well-defined mode at 10·5 cm. *may* indicate the I-group year class. The range of sizes observed was post-larvae (< 5 cm.) up to 19 cm. (see Fig. 36).

The depth relations of this species are extremely interesting: although taken in shallow coastal waters, it did not seem to come quite so far inshore as the extreme littoral members of the group, and the range was very restricted. A single specimen was taken at a depth of 100 m., but the other records were grouped so closely around the effective mean depth of 26 m. that that figure is significantly different from the mean depths recorded for all the other species of nototheniiformes within our area (Fig. 42 and Table 36). Fig. 3 shows that the slope from the coast down to 80 or 100 m., where the plain of the shelf may be said to begin, is steep in the north, and though more moderately inclined in the south it still shows a far more obvious gradient than is to be found on the plain itself. It would seem that *N. canina* is confined to this 'first slope', and mainly to the upper portion thereof. It is further noteworthy that the species is not known from the other side of the deep water of the Falkland trough. None has as yet been recorded from the Falkland Islands. The probable ecological significance of this depth distribution becomes apparent when we come to consider the depth relations of the two species next to be discussed.

Notothenia jordani Thompson. In our catches this species was even more closely restricted to a southern area off the eastern entrance to Magellan Straits than was *N. canina*. Some of Thompson's types, however, came from farther north, in the Golfo san Jorge. He found them most abundantly in the same place as we did, off Cape Virgins, and also within the eastern end of the Straits themselves as far as the first narrows. It will be noted that we did not find the species very plentiful; forty-three in the small beam trawl was the only large catch:

WS90	2	*WS834*	14
WS833	9	*WS836*	43 (in BTS)

N. jordani is a small species, the mean length of our specimens being 13·8 cm. with $\sigma_M^2/N = 0{\cdot}2386$.

The pooled length frequencies show one strong mode at 16 cm. which probably represents II-group fish. Hints of submodes at 7 and at 12 cm. may indicate the 0- and I-groups. The extreme range in length observed was 6–21 cm.

The mean depth at which we captured *N. jordani* was 54 m., and the difference of 28 m. deeper than the mean for *N. canina* is statistically significant. The extreme depth range observed was 27–82 m. Thus the depth distribution seems to be very restricted, the species being confined almost entirely to the lower half of the 'first slope', not spreading out on to the plain of the shelf or overlapping very much on to the territory of *N. canina* which, as we have seen, frequents the upper half of the 'first slope'. In our catches the difference in mean length of *N. jordani* (13·8 cm.) and *N. canina* (10·1 cm.) is statistically significant. Possibly we have here an example of the general rule 'larger fish in deeper water'—so familiar within the limits of single species having wide depth distributions—operating interspecifically, for the regional distribution of these two species is so nearly coincident that the difference in depth distribution will be the main factor tending to prevent territorial overlapping

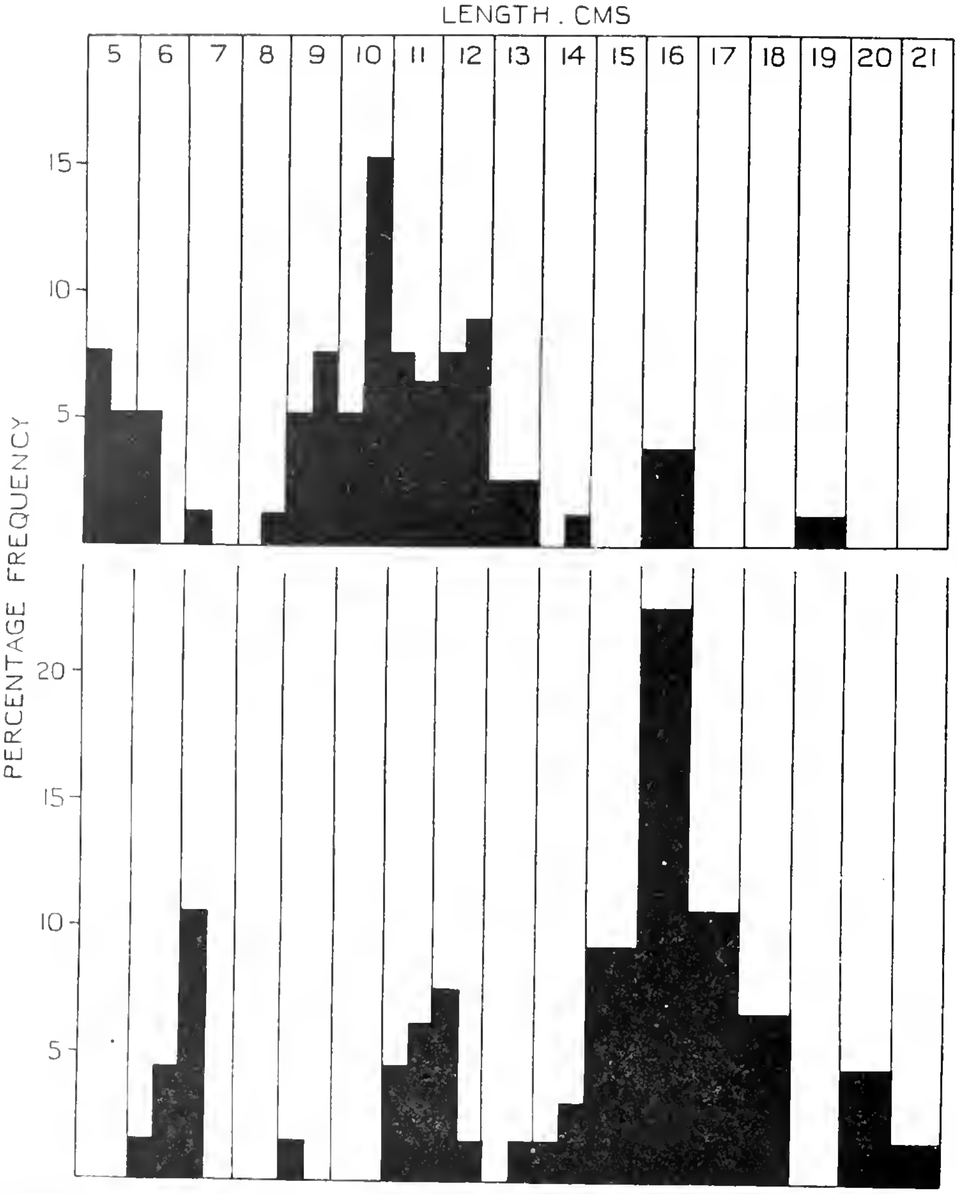

Fig. 36. Percentage length frequencies of *Notothenia canina* and *N. jordani*—late summer stations pooled.

between them. The ecological advantage of a system tending to lessen competition between two species so nearly related in size and habits may be considerable. The size difference, small as it is, is also apparent in the position of the modes that probably signalize the I-group year classes of the two species. From Fig. 36 it can be seen that these occur at 10·5 cm. in *N. canina* and at 12 cm. in *N. jordani*. It is also noteworthy that, like *N. canina*, *N. jordani* is not known from the Falkland Islands themselves, being apparently unable to cross the comparatively deep water of the Falkland trough.

Notothenia tessellata Richardson. This also is a small coastal species, and an inhabitant of the 'first slope' in the southern region, but it was not taken in the same localities as *N. jordani* and *N. canina*. It seems to favour more exposed coasts where the slope is steeper. In our catches it was found most frequently to the north of the Falkland Islands and around Cape Horn, but it is also known from the Magellan Channels and southern Chile (Norman, 1937, p. 73). Bennett's notes, quoted by Norman, show that it is quite common inshore at the Falkland Islands during the summer, but it is unpopular as food, though easily caught:

WS72	8	*WS872*	1	WS582	11 (on LH)
WS73	6	51	6 (in OTL)	WS583	8 (in BTS)
WS75	55	55	1 (in BTS)	Puerto Bueno	? (on LH)
WS83	28	222	1 (in TNL)	B. s. Nicholas	2 (on LH)
WS84	1	223	3	Field Anchorage	3 (on LH)
WS756B	1	724	10 (in seine)	Port Stanley	9 (by A. G. B.)
WS802B	1	WS576	1	New Island	8 (by J. E. H.)

The sizes of *N. tessellata* taken by us show complete overlap with *N. jordani* with modes, possibly indicative of age groups, at 11 and at 15 cm. They seem to run a little larger than *N. jordani* (our largest specimen of *N. tessellata* was 29 cm. long), but our samples are insufficient to show whether this is a constant feature. The effective mean depth at which *N. tessellata* was captured (73 m.) is, however, significantly different from that at which *N. jordani* was taken (Table 36). Indeed, this figure differs significantly from those for all the other nototheniiformes here studied. Frequenting more exposed coasts with a steeper slope, this species ranges more widely (into littoral waters on the one hand and down to the plain of the shelf on the other) than the 'first slope' dwellers previously mentioned. The resulting narrowing of the polygon of depth frequency shows this (Fig. 42).

Notothenia brevicauda Lönnberg. This small species was never taken in the trawl and appeared to be restricted to very shallow littoral waters at the Falkland Islands and in the Magellan Channels. Here the deep water of the Falkland trough does *not* seem to have limited dispersal as in *N. canina* and *N. jordani*. Possibly detached bodies of floating kelp, such as are frequently met with at great distances from land in the southern ocean, may provide means of dispersal for habitually littoral species, though they would be less readily available to fishes normally living at slightly greater depths on the 'first slope':

Port Stanley	1 (by A. G. B.)	New Island	1 (by J. E. H.)	56	2 (in BTS)

Norman (1937, pp. 74–5) thought that two of the types of *N. longicauda* Thompson, from shallow water on the mainland coast, were referable to *N. brevicauda* Lönnberg, and that seven others from Albatross St. 2771 at a depth of over 100 m. (of which he saw one that was too decomposed for comparison) probably belong to the species he describes as *N. guntheri* Norman. The very restricted deeper depth distribution of the latter, unhesitatingly identified by Norman in our catches, makes it seem probable that his view is correct (cf. Fig. 42). The two are clearly distinguishable (from Norman's descriptions) by the extent of the posterior rays of the dorsal and anal fins. These overlap the caudal in *N. brevicauda* Lönnberg, while in *N. guntheri* Norman they do not.

Notothenia guntheri Norman. This small species, named after E. R. Gunther by Norman, is mainly an inhabitant of the plain of the shelf, in the southern region. It was recorded from the intermediate region twice, but is not yet known to occur north of 49° S:

WS86	232	WS98	2	*WS814*	1
WS87	1	*WS225*	1	*WS825*	2
WS93	21	*WS781*	1	*WS841*	1
WS97	4	*WS804B*	1	652	2 (in OTL)

The depth distribution (Fig. 42, Table 36) is remarkably constant, suggesting that *N. guntheri* frequents the plain of the shelf at all seasons, with little migratory movement. There is no evidence of any migration into deeper water in winter, such as can clearly be shown for *N. ramsayi*. The effective mean depths for *N. ramsayi* and *N. guntheri* (151 and 147 m. respectively) are significantly different, but their close similarity masks an extremely wide difference in the dispersion of the depth frequencies from which they are derived. This is demonstrated by the shapes of the depth-frequency polygons in Fig. 42, and becomes fully apparent when the seasonal migration of *N. ramsayi* is shown in detail, when we remember that no hint of any such movement is given by our records of *N. guntheri*. It is interesting to note that the seasonal migration of *N. ramsayi* is reflected in a dumbbell-shaped polygon when the results of all seasons are lumped as in Fig. 42, just as was found with *Raja brachyurops*, a ray which also migrates over the shelf edge in winter (Fig. 18). By contrast the non-migrating *Notothenia guntheri* shows a very squat kite-shaped polygon reflecting the narrowness of the depth range over which that species was observed.

N. guntheri has not yet been recorded outside the area of our trawling surveys. Little can be deduced from our measurements of the species beyond the fact that it seems to be a small one; our largest specimens were 20 cm. long. Unlike the small species inhabiting shallow depths it was captured almost entirely in the trawl, so that all but the largest specimens were presumably outside the selective action of the gear used. A strong mode at 16–17 cm. in the only large catch may indicate a year class, probably the largest well-defined one (perhaps II-group). There is just a hint of another at 12 cm. (? I-group), which suggests a growth rate similar to that of other *Notothenia* spp. of comparable size. There is also a slight suggestion of conformity with the behaviour of several other members of the group in the fact that the only considerable concentrations of *N. guntheri* were met with in autumn, while at several summer stations it was taken singly, suggesting wide dispersal at that season.

Notothenia ramsayi Regan. This was the commonest fish trawled by us in the area investigated: 9665(+) individuals were recorded, a number which just exceeds the combined totals for *Macruronus* (4953) and *Merluccius* (4704). As a result of the smaller size of the *Notothenia*, however, the weight of hake taken was five times as great, while even the slender *Macruronus* weighed 2½ times as much. It is of course highly probable that the Falkland herring is present in vastly greater numbers than even *Notothenia ramsayi*, but we have no means of assessing the relative abundance of such small semi-pelagic clupeoids *vis-à-vis* demersal fishes. Captures of *N. ramsayi* in the 'Trawl+accessory nets' were as shown on opposite page.

It can be seen that *N. ramsayi* was very widely distributed over the plain of the shelf, and (in autumn and winter) beyond the shelf edge. Unlike most of the nototheniiformes caught in the trawl, which show a strong preponderance to the southward, this species appeared to be almost equally abundant in the northern and intermediate regions.

The smallest individuals were found mainly to the north in relatively shallow water, but fish almost certainly less than two years old were plentiful at times in the southern region. The larvae, presumably denatant, must be carried northwards by the prevailing current, and it is thus probable that the fry, by tending to work inshore, are assisted southwards by the counter-current. Without some such mechanism it is difficult to see how the species is maintained within its ecological norm, for the contranatant abilities of the young fish cannot be great during their second year of life (cp. E. S. Russell, 1937, p. 321).

WS71	125	**WS218**	232	WS787	140	*WS813*	10
WS72	4	WS219	8	**WS788**	1	*WS814*	3
WS73	90	WS220	26	**WS789**	2	*WS815*	8
WS76	42	WS222	19	**WS790A**	4	*WS816*	20
WS77	3	WS223	1	**WS790B**	3	*WS817A*	20
WS78	2	*WS225*	27	**WS791B**	57	*WS817B*	22
WS79	125	WS226	1	**WS792A**	432	*WS819A*	1
WS80	42	WS234	22	**WS792B**	432(+)	*WS823*	23
WS81	74	WS235	4	**WS793**	220	*WS824*	14
WS83	136	**WS237**	47	WS794	85	*WS825*	4
WS84	1	*WS239*	24	WS795	70	*WS837*	7
WS85	5	*WS242*	1	WS796A	247	*WS838*	1
WS86	1010	*WS243*	25	WS796B	22	*WS839*	1
WS87	1	*WS244*	30	WS797B	1	*WS847B*	2
WS90	4	*WS245*	35	WS797C	7	*WS848*	4
WS91	72	*WS246*	31	WS798	2	*WS849*	3
WS92	191	*WS248*	13	WS799A	48	*WS850*	7
WS93	18	*WS250*	1	WS799B	49	*WS851*	5
WS94	270	*WS756A*	2	WS800A	12	**WS853**	5
WS95	92	*WS756B*	14	WS800B	42	**WS855**	17
WS96	1	**WS764A**	9	WS801	1	WS857	4
WS97	1615	**WS764B**	41	*WS802A*	3	**WS858**	5
WS98	43	**WS765**	17	*WS802B*	1	**WS859A**	18
WS99	18	**WS771**	221	*WS804A*	16	**WS859B**	82
WS108	166	**WS772**	2	*WS804B*	41	**WS860**	4
WS109	10	WS773	8	*WS805*	6	WS862	42
WS210	27	WS774	11	*WS806*	104	WS864	15
WS211	63(+)	WS775	1	WS807	20	*WS866*	7
WS212	1	WS776	2	WS808	36	*WS868*	35
WS213	7	*WS781*	29	WS809A	64	*WS870*	8
WS214	1362	WS784	13	WS809B	3	*WS874*	16
WS215	1	WS785A	6	WS810	16		
WS216	117	WS785B	10	*WS811H*	14		
WS217	358	WS785C	4	*WS812H*	15		

We also captured *N. ramsayi* with 'Other gear' at the following stations:

51	35 (in OTL)	WS755	5 (in NR)	WS856	3 (in BTS)	WS871	1 (in BTS)
652	2 (in OTL)	WS767	10 (in NR)	WS861	1 (in BTS)	WS874	1 (in NR)
WS750	1 (in NR)	WS779	1 (in NR)	WS863	16 (in BTS)		
WS752	1 (in NR)	WS832	6 (in NR)	WS865	23 (in BTS)		
WS754	1 (in NR)	WS852	12 (in BTS)	WS867	15 (in BTS)		

N. ramsayi was rarely abundant in depths of less than 100 m., and never observed by us in depths of less than 50 m. The 'effective mean depth' was found to be 151 m., but the dispersion was very wide as can be seen from the diagram in Fig. 42. It will also be noted that the depth-frequency polygon tends towards the dumbbell shape, though the upper mode is by far the greater. In view of our findings with *Raja brachyurops* it was therefore obviously desirable to test the possibilities of a seasonal migration over the shelf edge in order to account for this. The data were arrayed by seasons in 50 m. depth categories and relative abundance, as indicated by numbers of *N. ramsayi* per hour's trawling, was computed for each.

The results shown in Table 31 are also indicated diagrammatically in Fig. 37. The graphs in the top half of this figure seem sufficient to show that the very varied amount of trawling within individual depth categories does not affect the main result; namely that *N. ramsayi* shows a well-marked migration into deep water over the shelf edge in winter and is relatively most numerous on the shelf in summer.

Actual numbers of *N. ramsayi* were highest in autumn, at all but the greatest depths. Nearly half the rich hauls of more than 100 individuals and all three exceptional hauls of more than 1000 individuals were obtained at that season. From this it seems safe to infer that schooling of *N. ramsayi* is most marked during autumn.

Table 31. *Seasonal variation in relative abundance of* Notothenia ramsayi *at different depths*

Season		Depth groupings, m.									
		1–50	51–100	101–150	151–200	201–250	251–300	301–350	351–400	401–450	>450
Spring	Hours trawling	*0*	*6*	*8*	*0*	$\frac{1}{4}$	*1*	*0*	*0*	*0*	*0*
	N. ramsayi per hour	0	**39**	14	0	8	8	0	0	0	0
Summer	Hours trawling	*2*	*32*	*57*	*7*	*5*	*5*	*5*	*1*	*2*	$\frac{1}{4}$
	N. ramsayi per hour	0	8	**37**	16	5	0	$\frac{1}{5}$	0	$\frac{1}{2}$	0
Autumn	Hours trawling	$\frac{1}{2}$	*8*	*25*	*7*	*6*	*1*	*0*	*0*	*0*	*0*
	N. ramsayi per hour	0	11	157	40	**238**	8	0	0	0	0
Winter	Hours trawling	*0*	*1*	*9*	*6*	*7*	*4*	*1*	*0*	*0*	*0*
	N. ramsayi per hour	0	0	49	29	20	**67**	0	0	0	0

An investigation of the mean lengths within depth categories at each season showed that there was a significant increase of size with depth. The fish caught between 201 and 250 m., and 251 and 300 m., in winter, do not show this; but all the other observations, taken in pairs successively (twelve pairs in all) show the deeper sample of the pair to contain significantly longer fish (Table 32). It is therefore clear that *N. ramsayi* conforms to the general rule 'larger fish in deeper water'.

Table 32. *Variation in mean length of* Notothenia ramsayi *at different depths during each of the four seasons of the year*

Depth range m.	Spring		Summer		Autumn		Winter	
	Mean length cm.	σ^2_{3n}/N	Mean length cm.	σ^2_{3n}/N	Mean length cm.	σ^2_{3n}/N	Mean length cm.	σ^2_{3n}/N
1–50	None	—	None	—	None	—	None	—
51–100	8·9	*0·0270*	13·0	*0·2107*	16·7	*0·2221*	None	—
101–150	11·8	*0·1891*	13·9	*0·0190*	21·9	*0·0045*	23·4	*0·0348*
151–200	None	—	17·8	*0·5113*	22·3	*0·0928*	24·8	*0·0927*
201–250	20·5	*0·1250*	26·9	*1·3578*	27·5	*0·0089*	24·2	*0·1386*
251–300	26·9	*2·0763*	None	—	31·0	*1·1250*	26·1	*0·0513*

These results also indicate that the vast majority of that part of the *N. ramsayi* population found beyond the shelf edge (i.e. in depths greater than 200 m.) are more than 20 cm. long. Reference to the actual frequencies shows that only sixty-three out of 1894, or 3·3 %, of the fish captured over the edge were less than 20 cm. long. The winter migration to deeper water is thus almost entirely confined to the larger fish that, as will presently be shown, are almost certainly more than two years old.

The numerous length-frequency data available for *N. ramsayi* can only be used to test the probable ages of the younger fish, by Pettersen's method. It was rarely possible to sex the individuals, owing to pressure of work upon the more obviously useful species, and, when sexing was achieved, it was found that a very large majority of the larger fish (of more than 25 cm.) were females. It is therefore almost certain that after maturity is reached the male and female growth rates diverge, the females growing the faster. Consequently one cannot base any conclusions as to age groups or growth rate upon the length frequencies of the larger fish in unsexed data. If the mature males are considerably smaller than the females, the apparent excess of the latter will in the main be accounted for by the selective action of the net. For the younger stages, however, the rich autumn hauls (many of them taken in the 'accessory nets') furnish length-frequency data that seem to show age groups with some certainty, judging by the consistency with which modes recurred at the same lengths.

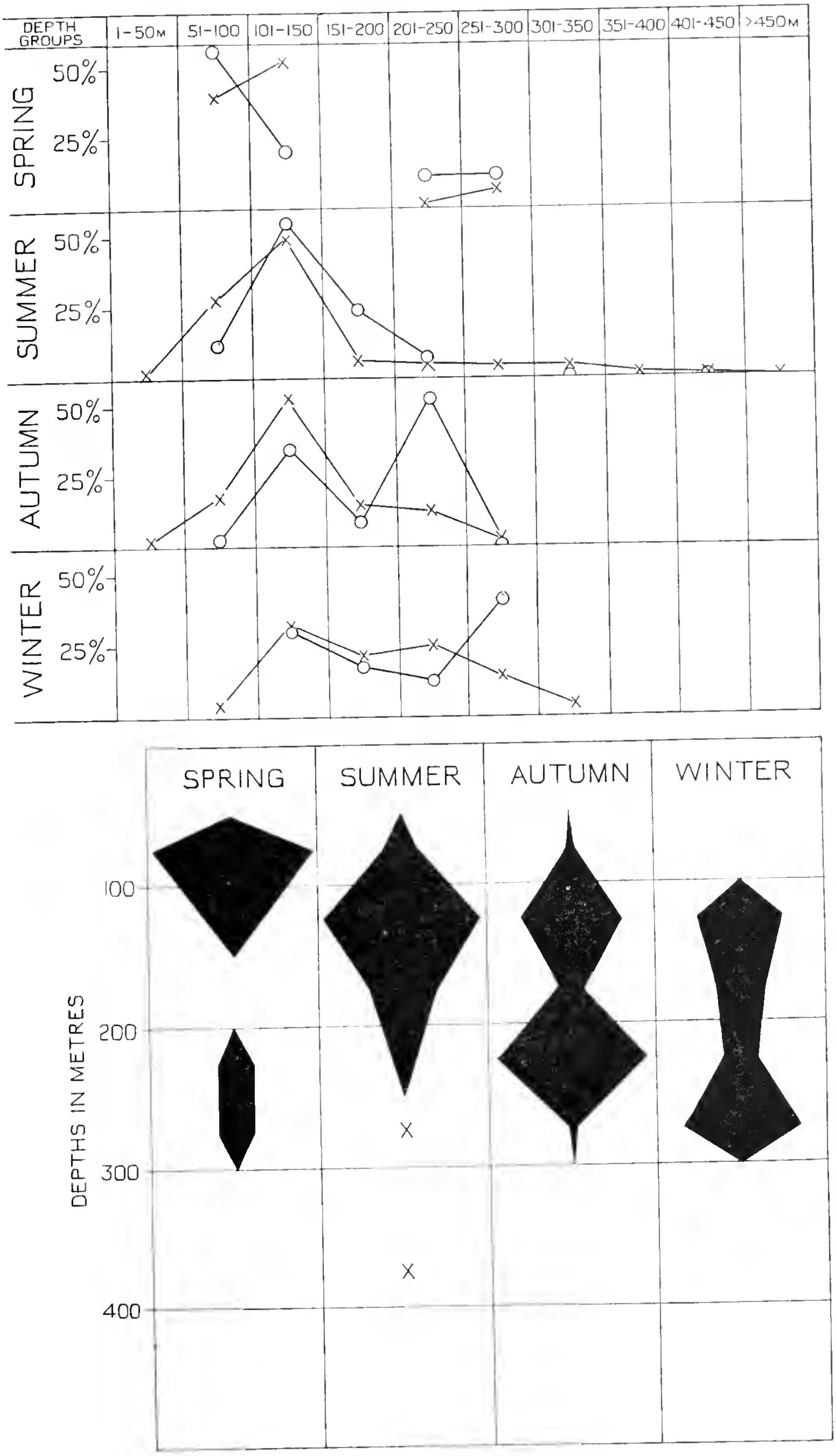

Fig. 37. Depth relations of *Notothenia ramsayi*. Above: relative abundance of fish caught within each depth-grouping at each season (circles), and the relative amount of time spent trawling within the same limits (crosses). Below: widths of polygons are proportional to the relative abundance of fish within the limits shown. (Data from Table 31 transposed to a percentage basis for comparison.)

We have no extensive autumn data for the smallest *Notothenia ramsayi*, but the pooled length frequencies of spring samples taken in 51–100 and 101–150 m. show such strong modes about 8–10 cm. (with the larger fish in the deeper water) that it is reasonable to assume that they represent a year class. These fish are thought to have been almost one year old—0-group becoming I-group (Fig. 38).

In autumn we obtained eleven rich hauls of between eighty and 1616 individuals of this species, and on plotting the percentage length frequencies (Fig. 39) it appeared that modes at around 14–16 and 22–23 cm. recurred with such consistency that there can be little doubt that they represented year classes. They are thought to indicate I-group and II-group fish respectively. The scale of the figure is necessarily much reduced, in order to permit comparison of all the samples on one page. Table 33, summarizing the important points arising from Fig. 39, and giving relevant geographical data, has been prepared to cover any loss of information due to the unavoidably small scale of the figure.

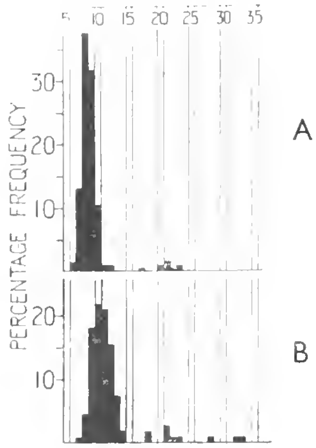

Fig. 38. Percentage length frequencies of *N. ramsayi* taken (A) between 51 and 100 m., and (B) between 101 and 150 m., in spring.

It will be seen that clear evidence of either or both of the two year classes mentioned is provided by all but three of these samples notwithstanding their diverse locations. At St. WS83 there was a strong mode at 17 cm.—considerably higher than the modal values for most of the presumed I-group fish captured around that time, which were at 14 and 15 cm. It is believed that this is explained by the geographical position of St. WS83—close in to, but on the southern side of, the Falkland Islands, considerably farther south than any other station at which such small *N. ramsayi* have been taken in quantity. From the general distribution of the species as already described it seems at least highly probable that only the largest members of the I-group would be likely to penetrate so far south. This notion is perhaps strengthened by the strong 14 cm. mode shown by the sample from St. WS73, almost equally close in to the islands, but to the *north* of them.

The very rich sample from St. WS97 yielded length frequencies which are not incompatible with the idea that the II-group predominated, but the mode is ill-defined, as stated in Table 33. The suggestion that this may be due to the slower growth rate of mature males as compared with females is strongly supported by the fact that such sexually differentiated growth is known to take place in various other fishes (e.g. hake).

Finally, at the only deep station at which a large haul of *N. ramsayi* was secured in autumn, St. WS214, it seemed that we were dealing with an altogether larger age group (? III-group) with the mode at 27 cm. This would be in full accordance with our findings as to the general relation between depth and size of fish where *N. ramsayi* (and many other species) are concerned.

Considering these results in conjunction with the general distributional data, it seems probable that early growth of *N. ramsayi* takes place somewhat as follows. The fish probably hatch in early summer and grow rather more than 10 cm. in their first year of life, at least 8 cm. in their second year and 6 cm. in their third. At this point maturity is probably reached and no reliable conclusions can be drawn from unsexed data, for it is probable that mature females grow considerably faster than males, but there is some evidence suggestive of a 4–5 cm. increment during the fourth year.

I have included this brief and admittedly speculative suggestion as to growth rate in *N. ramsayi* because it will at worst provide a working hypothesis if any future work on the shelf is possible, and we know so little of the growth of *any* of the fishes in southern temperate waters.

Several records of the stomach contents of *N. ramsayi* were made in autumn and winter, when some 75% of the fish contained recognizable food. The number of times food of each category was recorded, and an arbitrary weighting system (based on some contemporary volumetric records) which provides some approximation to relative values of major food categories, are shown in Table 34.

Clearly *N. ramsayi* is much more of a bottom-feeder than most of the other Patagonian species for which we have any data. Benthic Crustacea were the largest item in the dietary observed, and a considerable proportion of polychaetes were eaten. *N. ramsayi*, however, feeds heavily upon Falkland herring whenever opportunity offers, though the same might be said of almost every animal in the area capable of swallowing them, including such other typical bottom-feeders as *Cottoperca* and some of the rays. In winter some planktonic food was taken by some of the larger *N. ramsayi* far offshore, and this brings us to a point that the existing data are not adequate to solve, namely, that it is highly probable that in this species, as in so many other larger demersal fishes (cf. hake, cod, *Macruronus*, etc.), increased size and mobility is accompanied by a change-over from a carcinophagous to a fish diet. It is therefore probable that our approximate diagram really represents a sort of summation effect of the dietary of *Notothenia ramsayi* over the whole of its life, and that had it been possible to examine stomach contents of samples of small fish and larger fish separately, we should find the organisms occupying (roughly) the upper and lower halves of the diagram in very different proportions. I should expect the benthic invertebrates to be relatively more important in the smaller *Notothenia*, and fishes to predominate in the larger. Another notable feature is that no *Munida* were recorded from the stomachs of *Notothenia ramsayi*, but it is highly probable that they would have been had it been possible to make summer observations on this point.

Enough has been said to show that, if only on account of its small size, *N. ramsayi* is not likely to be of much value as human food in spite of its abundance within our area. The largest individuals of 35 cm. and upwards may attain a weight of a pound, and are not less palatable than the (rather insipid) larger Antarctic members of the genus. The average weight is little more than ¼ lb. however, and the majority of the trawled fish are just too large to be fried and eaten as 'sprats', a process that the crew of the 'William Scoresby' found most efficacious with the young fry some 10–12 cm. long. These were said to be '...exceedingly good, though the bones are rather hard. The flesh resembles that of whiting'.

N. ramsayi is of the first importance as a forage fish for larger and more useful species on the Patagonian Continental Shelf, being one of the main sources of food supply for hake and *Macruronus*, as we have already seen.

Notothenia wiltoni Regan. This species seems to be one of the more extremely littoral Nototheniiformes, though it may depart from the shallowest waters in winter. In our collections with 'Other gear' it was taken between 2 and 35 m. of water at the Falkland Islands and in the Magellan region, the mean depth being but 5 m.:

Port Stanley	45 (by A. G. B.)	56	2 (in BTS)
Field Anchorage	1 (on LH)	222	1 (in TNL)
55	1 (in BTS)		

None was taken at the regular trawling stations.

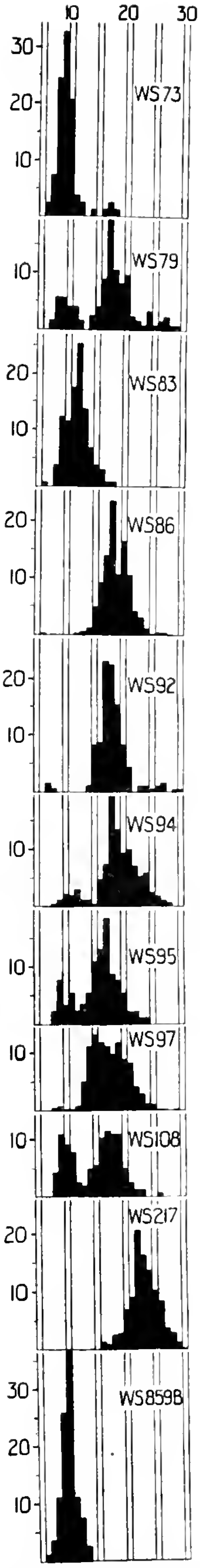

Fig. 39. Percentage length frequencies of *N. ramsayi* at autumn stations with more than eighty individuals, showing probable year classes.

Table 33. *Summary of the observations on length frequencies of* Notothenia ramsayi *at autumn stations shown in Fig. 39, with relevant geographical data*

Station	Date	Position		Distance in sq. m.		Depth m.	No. of *N. ramsayi* measured	Remarks
		Lat. S	Long. W	From Mainland	From Falklands			
WS73	6. iii. 27	51° 02′	58° 55′	226	20	121	82	Very strong mode about 14 cm., hint of a submode at 22 cm.
WS79	13. iii. 27	51° 01½′	64° 59½′	126	> 100	132	124	Fairly strong submode about 14 cm., mode at 22 cm.
WS83	24. iii. 27	52° 29′	60° 07¾′	232	13	133	131	Strong mode at 17 cm.
WS86	3. iv. 27	53° 53½′	60° 34½′	176	78	149	1010	Strong mode about 23 cm.
WS92	8. iv. 27	51° 58½′	65° 01′	125	> 100	144	183	Strong mode about 22–23 cm.
WS94	16. iv. 27	50° 00¼′	64° 57½′	107	0 > 10	118	269	Hint of a submode at 16 cm., mode at 23 cm. Higher values tail off rather gradually, owing perhaps to larger males growing more slowly than females of similar age
WS95	17. iv. 27	48° 58′	64° 45′	68	> 100	109	92	Submode at 14 cm., mode at 22 cm.
WS97	18. iv. 27	49° 00½′	61° 58′	165	> 100	146	1616	Ill-defined mode—the values at 19–22 and at 24 cm. all high. This is readily understandable if the hypothesis as to slower growth of mature males is accepted
WS108	25. iv. 27	48° 31′	63° 34′	94	> 100	119	166	Two well-defined modes at 14–15 and at 22–23 cm.
WS214	31. v. 28	48° 25′	60° 40′	199	> 100	214	1362	Strong mode at 27 cm. Here we seem to have a later year class (? III-group) dominant than at any of the other stations. Note that this is the only rich autumnal haul in deeper water
WS859B	25. iii. 31	45° 14′	61° 56′	142	0 > 10	108	81	Very strong mode at 15 cm.

Table 34. *Observations of stomach contents of* Notothenia ramsayi *in autumn and winter, and an approximate evaluation of the relative importance of the main food categories by arbitrary weighting (data of Fig. 40)*

Food category	Times recorded	Food category	Times recorded	Food category	Times recorded
Sagitta sp.	1	Mysidacea	2	Cephalopoda	1
Nemertinea	1	*Serolis* sp.	11	Ophiuroidea	2
Nereidae	2	Other Isopoda	3	Holothuria	1
Sabellidae	8	*Parathemisto*	1	*Clupea*	13
Terebellidae	4	Hyperiidae	1	*Notothenia* sp.	2
Other Polychaeta	5	Other Amphipoda	15	Other fish	2
		Euphausiidae	1		
		Paralomis granulosa	1		
		Eurypodius latreilli	7		
		Other Brachyura	1		

Major (grouped) food categories	Times recorded	Weighting factor	Relative importance	Relative importance as %
Polychaeta	20	× 1	20	6·7
Benthic Crustacea	41	× 3	123	41·1
Other benthic invertebrates	4	× 2	8	2·7
Planktonic invertebrates	4	× 1	4	1·3
Cephalopoda	1	× 8	8	2·7
Clupea	13	× 8	104	34·8
Other fish	4	× 8	32	10·7

N. wiltoni is somewhat larger than the shallow-water nototheniids discussed previously, attaining a length of 34 cm. with individuals of more than 20 cm. fairly common. It is very easily confused with small specimens of *N. ramsayi*, and resembles *N. longipes* Steindachner so closely that Norman (1937, pp. 80–2) found it impossible to give complete synonymies for the two species, and believed that they might yet prove to be identical. However, Norman was able to give characters that should prevent confusion with the deeper-water *N. ramsayi* in the future.

Bennett's interesting notes on the occurrence of this species in shallow harbour waters at the Falkland Islands are also quoted by Norman. It is common inshore during summer, becoming scarce in autumn, when the gonads are enlarged. Hence Bennett concludes that its departure may be for breeding purposes. *N. wiltoni* is known as 'rock-cod' locally, but this vernacular name, perhaps the most promiscuously applied of all fish names in English-speaking countries throughout the world, is also given to several other *Notothenia* spp. in the Falkland Islands.

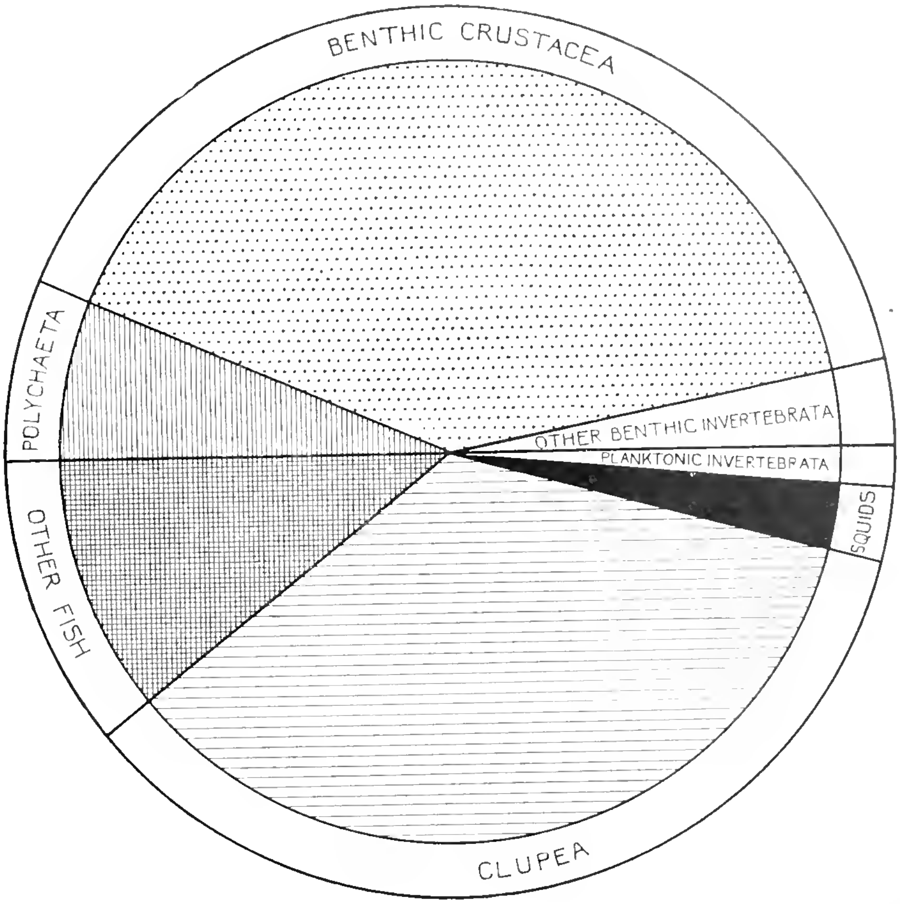

Fig. 40. Approximate relative importance of the main food categories of *N. ramsayi*, the data being arbitrarily weighted as shown in Table 34.

Notothenia longipes Steindachner. We have just mentioned the possibility of confusion between this species and *N. wiltoni*. Such scanty distributional evidence as we possess favours the view that they really are distinct. All the specimens referred with any confidence to *N. longipes* seem to come from the west coast of southern Chile or the western end of the Magellan channels, where they show a depth distribution rather similar to that of *N. canina* at the eastern end of the straits (Fig. 42) and very different from that of the more exclusively littoral distribution shown by *N. wiltoni* and various other *Notothenia* spp. We took no *N. longipes* at regular trawling stations, but specimens obtained as shown below gave an 'effective mean depth' of 43 m. with extreme range 12–78 m. Our largest specimen was 17 cm. long, but most of them were very small:

WS582	1 (on LH)	WS583	20 (in BTS)	Ringdove Inlet	1 (on LH)

Notothenia squamiceps Peters. The 'William Scoresby' did not capture any specimens of this small species, which seems to have an extremely littoral distribution at the Falkland Islands and in the Magellan region. The 'Discovery', however, obtained a few in the autumn of 1926, all from East Falkland and some with ripe eggs. None of these can have come from depths greater than 16 m. The largest specimen was but 12 cm. long:

53	3 (in RM)	55	1 (in BTS)	56	3 (in BTS)

Notothenia sima Richardson. This is yet another exclusively littoral species, taken plentifully by Mr A. G. Bennett with shore seines and traps in Port Stanley, and (rarely) by the 'Discovery' using the small beam trawl in very shallow water (10–16 m.); but it was never encountered at the regular trawling stations. Norman (1937, p. 85) quotes interesting observations by R. Vallentin that seem to show that this species spawns in littoral waters in spring or early summer, i.e. at quite a different time of year from that at which *N. squamiceps* was taken with eggs. *N. sima* is another small species. Bennett's largest specimen was 14 cm. long:

Port Stanley (Nov. and Feb.)	24 (in seine and trap, A. G. B. *coll.*)	55	2 (in BTS)
56	1 (in BTS)		

Notothenia cornucola Richardson. This species has been recorded at depths down to 35 m., but in the main it seems almost as exclusively littoral as the last two. It was never taken in the trawl, and with one exception (from Cape Horn) our few specimens were all obtained at the Falkland Islands. *N. cornucola* resembles *N. sima* very closely, but may be distinguished by the absence of scales on the lower part of the operculum (Norman, 1937, p. 85). Norman (p. 87) also quotes references from the literature that point to the possibility of an extended breeding season in *N. cornucola*. The record of this species from New Zealand is extremely doubtful, as Norman has shown, but it is known from southern Chile (northwards to Chiloe) and the Magellan channels in addition to the localities where we obtained specimens. The largest *N. cornucola* obtained by us was only 13 cm. long:

52	1 (on LH)	222	1 (in NRL)
53	1 (in RM)	Port Stanley	Several (A. G. B. *coll.*)
55	1 (in BTS)	New Island (West Falkland)	6 (J. E. H. *coll.*)
56	1 (in BTS)		

Notothenia elegans Günther. This little species with its slender body and proportionately large fins, so well figured by Col. Tenison (in Norman, 1937, fig. 42), cannot easily be confused with any of the other Patagonian Nototheniidae. It was the smallest nototheniid that seemed regularly to inhabit moderately deep water on the plain of the shelf and, rarely, beyond. This is shown by the depth-frequency distribution (Fig. 42). *N. elegans* seems, moreover, to have a more northerly regional distribution than most of the other species, having been recorded twice in the northern region, and more frequently in the intermediate than in the southern region in our catches. Too much stress should not be laid on this point, however, because on account of its shape and small size (we took none more than 12 cm. long) it is certain that our gear could not sample this species adequately. It was captured chiefly in 'Other gear' or in the accessory nets attached to the back of the trawl. *N. elegans* is doubtless eaten by larger fishes, but is probably not sufficiently common to rank high in importance as a forage species:

WS83	1	WS808	3	WS861	1 (in BTS)	WS878	11 (in NR)
WS93	1	51	4 (in OTL)	WS863	26 (in BTS)		
WS237	1	**WS767**	5 (in NR)	*WS867*	1 (in BTS)		
WS795	1	*WS836*	6 (in BTS)	WS873	1 (in NR)		

Notothenia macrocephala Gunther. Norman (1937, pp. 89–90) has shown that there seems to be no reason to doubt the identity of this species with examples from Kerguelen and New Zealand. It is one of two Nototheniids that seem to have a truly circumpolar *sub*-Antarctic distribution. The silvery young seem to live pelagically for a much longer period than those of most other members of the group, and this may have favoured wide dispersal of the species.[1] A striking illustration of this was afforded by the capture of nine specimens (up to 9 cm. long) at St. 63 in 48° 50′ S: 53° 56′ W, right out in the open South Atlantic some 300 miles NE · N of the Falkland Islands. These specimens were caught at the surface with a dip-net, and not by hand-lines as erroneously stated in Norman's report.

We got no *N. macrocephala* in the trawl—the sizeable adults seem to be mainly littoral in their habits—but some were captured with 'Other gear', and Mr Bennett secured numerous specimens with seine and hand-lines in Port Stanley. Bennett's notes, quoted by Norman (loc. cit.), show that the larger individuals are common inshore at the Falkland Islands, where they are known as 'yellow-bellies', and stay close inshore later in the year than most other Nototheniidae. He found them good eating though they are rarely used as food. At the Falklands they attain a length of over a foot and 1 lb. weight. The depth distribution shown in Fig. 42 refers to the larger individuals, taken only in littoral waters, and excludes the pelagic young which (as we have seen) may at times be met with far out at sea over oceanic depths.

We obtained specimens of *Notothenia macrocephala* as follows:

63	9 (in dip-net)	222	1 (in TNL)
Port Stanley	8 (+several not preserved, A. G. B. *coll.*)	229	1 (in N100H)

From Phillipps (1921, p. 123) we learn that in New Zealand this fish goes by the name of 'Maori chief', but in Wellington, where a few were marketed in autumn, the fishermen know it as 'More-pork'. The fish should not be confused with the hairy owl (*Ninox novae-zelandiae*) or the Tasmanian night-jar (*Podargus cuvieri*) that go by the same vernacular name.

Notothenia microlepidota Hutton. We did not obtain any specimens of this species, which is, however, of special interest because Norman (1937, pp. 90–1) believed that some Patagonian specimens, variously described, and authentic New Zealand ones, were identical. 'There is, thus, a second species common to the Patagonian and Antipodes regions.'

Dissostichus eleginoides Smitt. This is the largest of the Patagonian Nototheniidae. Superficially it bears a very strong resemblance to a hake, but Norman (1937, p. 92) found the skeletal relationship to *Notothenia* very close. It seems to be a rare fish in the Patagonian region, and we captured nine specimens only. *Dissostichus* was always taken in the trawl, never in 'Other gear'. It occurred at such widely divergent depths that the depth relations could not be expressed by the methods used for other Nototheniiformes, and individual occurrences are plotted against depth in Fig. 42. The largest specimen, which was 90 cm. long and weighed 7710 g. (nearly 17 lb.), was taken in 297 m. At shallower depths the specimens showed regular increase in size with depth, ranging from a specimen of 13 cm. in 84 m. to one of 33 cm. in 172 m., but two five-pounders (about 64 cm.) were taken in one of the deepest hauls made (418 m.). It would seem that at most seasons only immature individuals of this species are to be found on the shelf, the larger fish ranging the deep water beyond the edge. They *may* migrate to shallower water to spawn, but we lack any direct evidence on the matter. Our larger specimens showed a steady increase in ponderal index with increasing length, from about 0·7 at 47 cm. to a value exceeding unity for the largest fish caught:

WS75	1	WS97	1	WS98	3	*WS245*	2	*WS839*	2

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[1] It is quite probable that adequate search would reveal the presence of *N. macrocephala* at Gough Island, the Crozets, Marion and Prince Edward Islands, and perhaps even at St Paul's Island and New Amsterdam. Our knowledge of the fish faunas of the isolated sub-Antarctic islands is deplorably fragmentary, especially in the Indian Ocean sector.

D. eleginoides is one of the few Patagonian fishes known also from the Antarctic Zone. It has been taken among the islands off Graham Land (Vaillant, 1906, pp. 36–9).

Eleginops maclovinus (Cuvier and Valenciennes). This genus may at once be distinguished from others of the family Nototheniidae by the entire absence of a lower lateral line. *E. maclovinus* is a sizable fish, and appears to be exclusively littoral in its habits. We never captured any in the trawl. Specimens were secured with 'Other gear' as follows:

724 10 (in seine) Connor Inlet 2 or 3 (on LH) WS586 1 (on LH)

In addition to these, Mr A. G. Bennett collected six specimens for Norman's report by seine-netting in Port Stanley harbour, mostly at Weir Creek.

Bennett also provided valuable notes on the habits of the fish which Norman (1937, pp. 93, 94) quotes at length. The species is known locally as 'mullet', and this vernacular name is justified not only by its strong superficial resemblance to true mullets (*Mugil* spp.), which are absent from the region, but also by its habits. Notable among these is its tendency to run right up into the mouths of fresh-water streams on the last of the rising tide. Bennett tells us that it may grow up to 2 ft. long, but unless this length is at times considerably exceeded, his figure of 15 lb. for the maximum weight, quoted by Norman, must be a mistake. A fish 2 ft. long and 15 lb. in weight would have a ponderal index just over 3·0 (calculated from $K = w\,(\text{g.})/l\,(\text{cm.})^3 \times 100$),[1] and it is clear that no fish approaching the proportions of *Eleginops* could give even half this value. Authentic weight records of smaller specimens give ponderal indices from 0·69 to 0·85, and if we assumed an index of 1·0 for a 2 ft. specimen its weight would be just 5 lb. Conversely, even if we assumed an index as high as 1·25, a 15 lb. fish would be no less than 32 in. long. I believe that in all probability Bennett actually wrote 5 lb. and that some error crept in subsequently.

Eleginops is eaten quite frequently at the Falkland Islands, but often has a muddy taste. Otherwise it would be a promising subject for small-scale local exploitation by seine-netting. It extends round both coasts of the mainland of South America from the River Plate in the east to *northern* Chile in the west—much farther towards the equator than most other Nototheniidae.

HARPAGIFERIDAE

In his later report on the coast fishes of the Antarctic Zone Norman (1938, p. 43) places *Harpagifer*, with four other (exclusively Antarctic) genera in this separate family and not, as heretofore, in the Nototheniidae. The chief characteristic of the family is absence of scales on the body.

Harpagifer bispinis (Schneider). This is the only member of the family found in the sub-Antarctic Zone. To the southward it has a wide distribution in the northern part of the Antarctic Zone, having been recorded from Graham Land and almost all the isolated island groups (Norman, 1938, pp. 52–3). Norman's description of it as mainly littoral (and frequently intertidal) in habit, applies accurately enough in the Patagonian region, though even there we have taken it down to 95 m.; and the depth relations, shown in Fig. 42, show it closer to the 'first-slope' dwellers than to the exclusively littoral species of Nototheniidae. Farther south, however, where the intertidal zone is usually small and subject to ice action, *Harpagifer* usually occurs at greater depths, although it is true enough that it

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[1] The high 'condition factors' quoted in some salmon literature (of the order 36–40 or more) are obtained from the formula $w\,(\text{lb. \& fractions})\; l\,(\text{inches})^3 \times 10{,}000$. Menzies' Scottish 'coefficients' make use of the same heterogeneous British units, but get rid of the unwieldy decimal ciphers resulting from the first term of the formula by dividing by 0·00036, a figure just below the mean for 'normal' east of Scotland salmon. This has the effect of bringing all the values close to unity (and close to those obtained by direct use of the metric formula). His system is perhaps ideal so long as we wish to consider salmon only (and only east of Scotland salmon!) but the principle of dividing by the mean value implies that the factors for any given species (or local race) of fish will be grouped close around unity. If we wish to visualize the difference in the ratio weight to cube of length between fish of diverse form it is not possible to use his method, whereas direct application of the metric formula permits this, and with less heavy arithmetic. *A propos* the immediate problem above, Menzies' figures (1925, p. 190) show that a 24 in. salmon should weigh about 5 lb. 2 oz.

keeps close in to the land. In the Patagonian region we captured specimens of this very small species at one trawling station only: WS89, in shallow water, where three were taken in one of the 'accessory nets'. Other specimens were obtained for Norman's 1937 report as follows:

Port Stanley	24 (under stones, A. G. B. *coll.*)	*WS749*	3 (in NR)
New Island (West Falkland)	3 (J. E. H. *coll.*)	*WS832*	1 (in NR)

None of these exceeded a length of 10 cm. If readily available between tidemarks at the Falkland Islands, *Harpagifer* might be useful as bait.

CHAENICHTHYIDAE

Champsocephalus esox (Günther). This species occurred with some frequency in trawl catches on the rough ground near the Falkland Islands in the southern region. A single large specimen was taken farther north, at St. WS97 in 49° S:

WS71	30	*WS95*	1	*WS834*	1
WS73	6	*WS93*	2	*WS837*	1
WS75	29	WS97	1		
WS76	1			51	22 (in OTL)
WS81	1	*WS756B*	2	724	2 (in seine)
WS83	41	*WS802B*	1	Port Stanley	3 (A. G. B. *coll.*)
WS84	2	*WS823*	5		

Most were taken in autumn, and none during the winter survey when a large proportion of the stations were worked in deep water beyond the shelf edge. The species is, indeed, very much an inhabitant of the plain of the shelf, judging by the depth distribution shown in Fig. 42. From this it can be seen that while a few have been taken in shallow littoral waters there was only a single specimen from beyond the shelf edge. From Bennett's notes, quoted by Norman (1937, p. 96), it would seem that if there is any inshore migration of *Champsocephalus*, it will take place in late summer or autumn, for his records of the infrequent capture of the species in littoral waters at the Falkland Islands all date from that season.

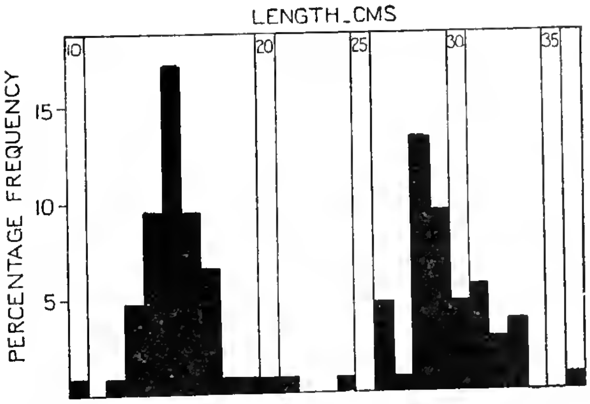

Fig. 41. Percentage length frequencies of *Champsocephalus esox* captured in autumn.

The length frequencies of our autumn-caught specimens (Fig. 41) show two very strong modes at 15 and at 28 cm. If these indicate year classes it follows either that this species is of extremely rapid growth,[1] or that an intermediate year class is entirely lacking in our samples. The presence of such an intermediate year class would, indeed, bring the growth rate into line with that observed for *Notothenia ramsayi*, a related fish of much the same size, but it is extremely difficult to see why such an intermediate age group should be absent from the grounds frequented by both younger and older fish of the same species. Moreover, in view of our extensive observations, coupled with those of Hamilton and Bennett in littoral waters, we should certainly expect to have found evidence of such a group somewhere if it actually exists.

Champsocephalus esox, which has near relatives in the Antarctic Zone, is excellent eating: much firmer and of better flavour than most Nototheniiformes. Unfortunately, we rarely captured it in any great quantity, and our largest specimen was only 36 cm. long, so that it is unlikely that the 'pike', as it is called in the Falkland Islands, could be exploited profitably.

[1] 14 cm. in its second year. Among better-known fishes of similar size such a rate is approached by estuarine pollack and whiting, which later descend to the sea (Hartley, 1940, pp. 47-50).

SUMMARY OF OBSERVATIONS ON PATAGONIAN NOTOTHENIIFORMES[1]

The survey of our observations on the distribution and bionomics of the individual species of Patagonian Notetheniiformes enables us to present some of the main features regarding the group as a whole in more concentrated form. Table 35 gives a list of all the species known from the area up to the time of the publication of Norman's report, and shows which were captured in our trawls or with 'Other gear', with brief notes on records of occurrence outside the area investigated.

Table 35. *List of the Patagonian Nototheniiformes, their occurrence in our material and their distribution outside the area surveyed*

Family	Species	Page references in Norman (1937)	A	B	C	Distribution outside the area
Bovichthyidae	*Cottoperca gobio* (Günther)	63–65	+	+	—	Southern Chile
	Bovichtus argentinus MacDonagh	65	—	—	+	Northwards to La Plata
Nototheniidae	*Notothenia macrophthalma* Norman	68–69	+	—	—	Holotype only, not yet known elsewhere
	N. trigramma Regan	69	—	—	+	Holotype only, not yet known elsewhere
	N. canina Smitt	69–70	+	+	—	Magellan Straits
	N. jordani Thompson	71–72	+	+	—	Magellan Straits
	N. tessellata Richardson	72–73	+	+	—	Magellan Straits, and southern Chile north to Chiloe
	N. brevicauda Lönnberg	74–75	—	+	—	Magellan Channels
	N. guntheri Norman	75–76	+	+	—	Not yet known elsewhere
	N. ramsayi Regan	76–80	+	+	—	Not yet known elsewhere
	N. wiltoni Regan	80–81	—	+	—	Magellan Straits
	N. longipes Steindachner	81–82	—	+	—	Magellan Straits, southern Chile
	N. squamiceps Peters	82–83	—	+	—	Magellan Straits
	N. sima Richardson	84–85	—	+	—	Magellan Straits
	N. cornucola Richardson	85–87	—	+	—	Magellan Straits, and southern Chile north to Chiloe, ? N.Z.*
	N. elegans Günther	87–88	+	+	—	Magellan Straits
	N. macrocephala Günther	88–90	—	+	—	Circumpolar sub-Antarctic
	N. microlepidota Hutton	90–91	—	—	+	Circumpolar, but not at Kerguelen
	Dissostichus eleginoides Smitt	91–92	+	—	—	Magellan Straits, Graham Land
	Eleginops maclovinus (C. and V.)	92–94	—	+	—	Up to River Plate on the east, and to northern Chile on west coast
Harpagiferidae	*Harpagifer bispinis* (Schneider)	94–95	+	+	—	Circumpolar northern Antarctic
Chaenichthyidae	*Champsocephalus esox* (Günther)	95–96	+	+	—	Magellan Straits (near relatives Antarctic)

A = taken in 'Trawl + accessory nets'; B = taken in 'Other gear' or by shore parties; C = not taken by the Expedition.
* See Norman (loc. cit.) for the doubtful records of this species in New Zealand.

In their regional distribution within our area, the group as a whole is a southern one. Of the deeper water species only the dominant *Notothenia ramsayi*, with *Cottoperca gobio* and *Notothenia elegans* were recorded in the northern region; and *Cottoperca* was much more plentiful in the southern region, while *Notothenia elegans* seemed to find its optimum in the intermediate region. *N. guntheri* appeared twice in the intermediate region, but 49° S was its northern limit among our observations, which was true also of *Dissostichus* and *Champsocephalus*, characteristically southern genera. Little can be said concerning the probable northern limits of the littoral species, owing to unavoidable lack of observations in Argentine territorial waters. *Eleginops* and *Bovichtus* are known to range far to

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[1] This supra-family grouping is convenient for purposes of this summary. It includes the families shown in the Table with other exclusively Antarctic ones. Elsewhere in this report I have avoided using such groupings, as many of them involve questions of classification that are still unsettled.

the north, and W. F. Thompson took *Notothenia jordani* in Grande Bay. We took young *N. macrocephala* in 48° 50′ S in the open ocean, but large individuals were obtained by us only in southern coastal waters. In New Zealand, however, adults of this species are known to range as far north as the southern coasts of North Island. All the other shallow-water Nototheniiformes were taken (by us) only in the southern region.

The Nototheniiformes are preeminently an Antarctic group, completely dominant over all other fishes in such small areas of the vast oceans south of the Antarctic convergence as are sufficiently shallow to support any coastal fish fauna. Their abundance and variety in the Patagonian region and their tendency to be distributed mainly near its southern limits, are consistent with the view that they have spread northwards, but we have seen that only *Harpagifer* and *Dissostichus* have species common to both zones. It thus seems probable that the Patagonian fish fauna has been insulated against invasion from the south for a very long time, and that the hydrological barrier of the Antarctic convergence provides too big a contrast in environment for the majority of such fishes to overcome.

Quite early in these investigations, when attention was focused on large species (notably hake) that migrate over long distances in a comparatively short space of time, we found it impossible to gain much by the study of depth distribution because of the very slight gradient on the plain of the shelf. This necessitated laborious calculations of the distance of each observation from the coast before we could attempt to follow the movements of such fishes. With the Nototheniiformes it is quite otherwise. Here we have a group consisting for the most part of fairly small bottom-living fish with limited powers of movement, and the study of depth distribution has helped a great deal in our attempts to gain some insight into their probable way of life.

The depth relations of the Patagonian species are summarized in Fig. 42, and the differences in the mean depths recorded are given in Table 36, with data sufficient to determine their statistical significance. The figure shows the effective mean depths and extreme ranges observed for all the species except *Dissostichus eleginoides*, our few specimens of which were so widely dispersed as to demand individual plotting. The distribution of all the species descending below the 50 m. level is also indicated by the black polygons. The widths of these are proportional to the relative abundance of each species within each 50 m. depth grouping. The littoral species are further indicated by stippling of the rectangle covering the whole of the observed depth range of each.

It will be seen that the species can be divided into three main groups according to their depth distributions:

I. Deep-water species found mainly on the plain of the shelf and rarely beyond the shelf edge: *Cottoperca gobio*, *Notothenia guntheri*, *N. ramsayi*, *N. elegans*, *Dissostichus eleginoides* and *Champsocephalus esox*.

II. ‘First-slope’ dwellers, rarely descending below 100 m., where the plain of the shelf may be said to begin: *Notothenia canina*, *N. jordani*, *N. tessellata*, *N. longipes* and perhaps *Harpagifer bispinis*.

III. Exclusively littoral species: *Notothenia brevicauda*, *N. wiltoni*, *N. squamiceps*, *N. sima*, *N. cornucola*, *N. macrocephala* (adults) and *Eleginops maclovinus* (*Bovichtus argentinus* may fit in here).

Within the first two groupings it proved possible to recognize further distributional trends, either regional or bathymetric, which serve to differentiate the species still further. As a result of this (always excepting the dominant and ubiquitous *Notothenia ramsayi*) most of the species show a distinctive distributional pattern that tends to minimize territorial overlapping between them. The possible ecological ‘advantage’ of this in lessening competition between species of similar size, may be one of the factors that has led to the slight modifications in food requirements and general habits that it must have entailed.

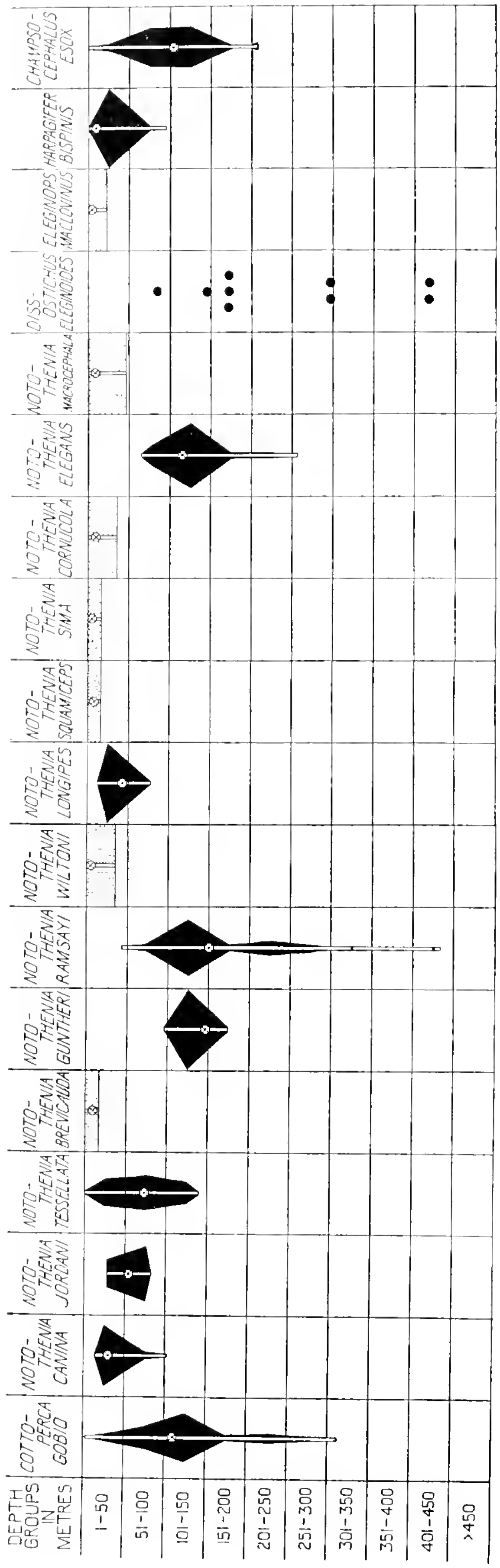

Fig. 42. Depth relations of Patagonian Nototheniiformes.

Table 36. *Patagonian Notetheniiformes: differences in effective mean depth and their significance*

Species	Nos. available and **effective mean depth**	σ^2_M/N	*Cottoperca gobio*	*Notothenia canina*	*N. jordani*	*N. tessellata*	*N. brevicauda*	*N. guntheri*	*N. ramsayi*	*N. wiltoni*	*N. longipes*	*N. squamiceps*	*N. sima*	*N. cornucola*	*N. elegans*	*N. macrocephala*	*Dissostichus eleginoides*	*Eleginops maclovinus*	*Harpagifer bispinis*	*Champsocephalus esox*
Cottoperca gobio	471 **130 m.**	5·3674	— —	+104 Sig.	+76 Sig.	+57 Sig.	+121 Sig.	−17 Sig.	−21 Sig.	+125 Sig.	+87 Sig.	+122 Sig.	+125 Sig.	+121 Sig.	+15 Sig.	+122 Sig.	— —	+126 Sig.	+121 Sig.	+26 Sig.
Notothenia canina	86 **26 m.**	2·6157	−104 Sig.	— —	−28 Sig.	−47 Sig.	+17 Sig.	−121 Sig.	−125 Sig.	+21 Sig.	−17 Sig.	+18 Sig.	+21 Sig.	+17 Sig.	−89 Sig.	+18 Sig.	— —	+22 Sig.	+17 Sig.	−78 Sig.
N. jordani	68 **54 m.**	3·4892	−76 Sig.	+28 Sig.	— —	−20 Sig.	+45 Sig.	−93 Sig.	−97 Sig.	+49 Sig.	+11 Sig.	+46 Sig.	+49 Sig.	+45 Sig.	−61 Sig.	+46 Sig.	— —	+50 Sig.	+45 Sig.	−50 Sig.
N. tessellata	163 **73 m.**	12·6844	−57 Sig.	+47 Sig.	+20 Sig.	— —	+64 Sig.	−74 Sig.	−78 Sig.	+68 Sig.	+30 Sig.	+65 Sig.	+68 Sig.	+64 Sig.	−42 Sig.	+65 Sig.	— —	+69 Sig.	+64 Sig.	−31 Sig.
N. brevicauda	4 **9 m.**	5·2500	−121 Sig.	−17 Sig.	−45 Sig.	−64 Sig.	— —	−138 Sig.	−142 Sig.	+4 Not	−34 Sig.	+1 Not	+4 Not	0 Not	−106 Sig.	+1 Not	— —	+5 Not	0 Not	−95 Sig.
N. guntheri	269 **147 m.**	0·1680	+17 Sig.	+121 Sig.	+93 Sig.	+74 Sig.	+138 Sig.	— —	−4 Sig.	+142 Sig.	+104 Sig.	+139 Sig.	+142 Sig.	+138 Sig.	+32 Sig.	+139 Sig.	— —	+143 Sig.	+138 Sig.	+43 Sig.
N. ramsayi	9798 **151 m.**	0·1999	+21 Sig.	+125 Sig.	+97 Sig.	+78 Sig.	+142 Sig.	+4 Sig.	— —	+146 Sig.	+108 Sig.	+143 Sig.	+146 Sig.	+142 Sig.	+36 Sig.	+143 Sig.	— —	+147 Sig.	+142 Sig.	+47 Sig.
N. wiltoni	50 **5 m.**	0·6168	−125 Sig.	−21 Sig.	−49 Sig.	−68 Sig.	−4 Not	−142 Sig.	−146 Sig.	— —	−38 Sig.	−3 Not	0 Not	−4 Not	−110 Sig.	−3 Not	— —	+1 Not	−4 Not	−99 Sig.
N. longipes	22 **43 m.**	4·9380	−87 Sig.	+17 Sig.	−11 Sig.	−30 Sig.	+34 Sig.	−104 Sig.	−108 Sig.	+38 Sig.	— —	+35 Sig.	+38 Sig.	+34 Sig.	−72 Sig.	+35 Sig.	— —	+39 Sig.	+34 Sig.	−61 Sig.
N. squamiceps	7 **8 m.**	5·0408	−122 Sig.	−18 Sig.	−46 Sig.	−65 Sig.	−1 Not	−139 Sig.	−143 Sig.	+3 Not	−35 Sig.	— —	+3 Not	−1 Not	−107 Sig.	0 Not	— —	+4 Not	−1 Not	−96 Sig.
N. sima	27 **5 m.**	0·2963	−125 Sig.	−21 Sig.	−49 Sig.	−68 Sig.	−4 Not	−142 Sig.	−146 Sig.	0 Not	−38 Sig.	−3 Not	— —	−4 Not	−110 Sig.	−3 Not	— —	+1 Not	−4 Not	−99 Sig.
N. cornucola	11 **9 m.**	7·4793	−121 Sig.	−17 Sig.	−45 Sig.	−64 Sig.	0 Not	−138 Sig.	−142 Sig.	+4 Not	−34 Sig.	+1 Not	+4 Not	— —	−106 Sig.	+1 Not	— —	+5 Not	0 Not	−95 Sig.
N. elegans	62 **115 m.**	7·9313	−15 Sig.	+89 Sig.	+61 Sig.	+42 Sig.	+106 Sig.	−32 Sig.	−36 Sig.	+110 Sig.	+72 Sig.	+107 Sig.	+110 Sig.	+106 —	— Sig.	+107 —	— Sig.	+111 Sig.	+106 Sig.	+11 Sig.
N. macrocephala	11 **8 m.**	20·3388	−122 Sig.	−18 Sig.	−46 Sig.	−65 Sig.	−1 Not	−139 Sig.	−143 Sig.	+3 Not	−35 Sig.	0 Not	+3 Not	−1 Not	−107 Sig.	— —	— —	+4 Not	−1 Not	−96 Sig.
Dissostichus eleginoides	9 **247 m.**	Too widely dispersed	— —	— —	— —	— —	— —	— —	— —	— —	— —	— —	— —	— —	— —	— —	— —	— —	— —	— —
Eleginops maclovinus	17 **4 m.**	1·1280	−126 Sig.	−22 Sig.	−50 Sig.	−69 Sig.	−5 Not	−143 Sig.	−147 Sig.	−1 Not	−39 Sig.	−4 Not	−1 Not	−5 Not	−111 Sig.	−4 Not	— —	— —	−5 Not	−100 Sig.
Harpagifer bispinis	34 **9 m.**	10·7526	−121 Sig.	−17 Sig.	−45 Sig.	−64 Sig.	0 Not	−138 Sig.	−142 Sig.	+4 Not	−34 Sig.	+1 Not	+4 Not	0 Not	−106 Sig.	+1 Not	— —	+5 Not	— —	−95 Sig.
Champsocephalus esox	147 **104 m.**	5·0456	−62 Sig.	+78 Sig.	+50 Sig.	+31 Sig.	+95 Sig.	−43 Sig.	−47 Sig.	+99 Sig.	+61 Sig.	+96 Sig.	+99 Sig.	+59 Sig.	−11 Sig.	+96 Sig.	— —	+100 Sig.	+95 Sig.	— —

This feature is best demonstrated by the 'first-slope' dwellers. Thus while *N. canina* and *N. jordani* inhabit much the same area off the mainland coast in the southern region, the latter was consistently found in slightly deeper water than the former. *N. tessellata*, with a depth distribution overlapping that of both the last-named species, was not found along the same coasts, but mostly in more exposed positions where the 'first slope' was steeper (e.g. round the Falkland Islands, where the other two species did not occur at all). *N. longipes*, if it is indeed a distinct species, seems limited to the western end of the Magellan Channels, while the others were found to the eastward, mostly along open coasts. Lastly, *Harpagifer bispinis* might almost have been placed in group III, for it is common intertidally at times, but we have taken it down to 95 m. in the Patagonian region; and in the Antarctic Zone, where it has a far more extensive distribution regionally, it would certainly be more accurately described as a 'first-slope' dweller.

The deep-water group consists mainly of larger fish, so that, partly owing to increased powers of movement, there is considerably more overlapping between the species. Considering the *Notothenia* spp. first, the two smallest, *N. elegans* and *N. guntheri*, seem to move but little and to remain on the plain of the shelf throughout the year. *N. guntheri* has its centre of distribution well to the south of that of *N. elegans*. *N. ramsayi*, dominant throughout and the largest of the genus in the region, was found to have a well-marked seasonal migration to deeper water beyond the shelf edge in winter. *Dissostichus eleginoides* was too rare to be studied on these lines. It is the largest by far of all the sub-Antarctic Nototheniiformes. Our large specimens were captured beyond the edge in very deep water, but smaller ones were taken on the shelf, so it may move inshore to spawn. *Cottoperca gobio* and *Champsocephalus esox* were mainly inhabitants of the plain of the shelf in the southern region, showing considerable overlap with *Notothenia ramsayi*, but although a few *Cottoperca* were taken beyond the shelf edge, neither of them seemed to show anything like the definite movement to deeper water of *Notothenia ramsayi*. Moreover, both *Cottoperca* and *Champsocephalus* were frequently taken in lesser depths than those to which *Notothenia ramsayi* normally penetrates—sometimes, indeed, in littoral waters.

The exclusively littoral group naturally show almost complete territorial overlapping, but their size differences may serve to lessen the competition among them. *N. brevicauda*, *N. squamiceps*, *N. sima* and *N. cornucola* are all very small species and no doubt compete for small invertebrate food; but *N. macrocephala* and *N. wiltoni* run to a fair size (30 cm. or more) as Patagonian Nototheniidae go, and here, doubtless, 'the great ones eat up the lesser ones'. *Eleginops maclovinus* may run up to 5 lb. weight, but its diet is unknown. It would be extremely interesting to see whether the convergent evolution evident in its close superficial resemblance to true mullets, and emulation of their powers of ascent into shallows and fresh water, extends also to the adoption of a vegetarian diet.

In the matter of size generally, the 'first-slope' dwellers provide a majority of the intermediates between the extremes shown by the smallest littoral species and the deep-water group. Thus, with certain obvious exceptions, the division by depth distribution is broadly reflected in a corresponding gradation in size, just as we have so often found within the limits of individual species.

It is not yet possible to say much concerning the growth of Patagonian Nototheniiformes. Length frequencies of *Cottoperca gobio* suggest approximately 7 cm. annual increments during the main growing period of that species, and in *Notothenia ramsayi* it seems fairly certain that increments of the order of 10, 8 and 6 cm. accrue during the first three years of life, with *perhaps* a 4 cm. addition in the fourth year. It is probable that in this species, as in hake, the males grow much more slowly than the females once maturity is reached. Among species of intermediate size, 7 (?+), 5 and 4 cm. increments during the first three years of life are suggested for *Notothenia jordani*. There is a possibility that further work might show *Champsocephalus esox* to be a fish of exceptionally rapid growth.

Most of the shallow-water Nototheniidae are abundant intertidally in summer, moving to slightly deeper water in winter. Thus they parallel the movements of the offshore species *Notothenia ramsayi* on to the shelf in summer and over the edge in winter. The larger, deeper-water species show increased tendency towards schooling in autumn, and it may be that some of them spawn then. There is a little direct evidence as to spawning time among the small inshore species, but this shows all possible ranges from spring spawning in *N. sima* to autumn spawning in *N. squamiceps*, with the possibility of an extended breeding season in *N. cornucola*. Among larger inshore species, *N. wiltoni* almost certainly spawns in the autumn at the Falkland Islands (Bennett) but in New Zealand *N. macrocephala*, the principal species common to both the Antipodean and Patagonian regions, is said by Phillipps (1921, p. 123) to spawn in September (spring).

GEMPYLIDAE

Thyrsites atun (Euphrasen). During the trawling surveys forty-five adult specimens of this large fish were captured. They occurred at six stations only, and twenty-nine of them at a single one of these (WS 847 B). All these captures were made fairly close in to the mainland coast in moderately shallow water, in late summer and autumn, and all but one of them in the southern region:

WS 96	1	*WS 833*	4
WS 812 I	1	*WS 847 A*	6
WS 812 II	4	*WS 847 B*	29

The lengths of these fish were very consistent, with the means 97·3 cm. for males (range 87–104 cm.) and 97·8 cm. for females (range 89–112 cm.). Females were more numerous than males, but the numbers are too small to support the suggestion that this is a constant feature, as it is in so many other fishes. Similarly, no significance can be attached to the slightly greater lengths attained by the females. At two stations *Thyrsites* was observed to have been feeding heavily upon *Clupea fuegensis* and *Thysanopsetta naresi*.

These fish were in prime condition: the values for K averaged 0·380, a high figure for a species of such slender proportions. The extreme range of K observed was 0·320–0·449. We should expect high values for K in autumn if the stock of *Thyrsites* off the east coast of Southern America spawn at the end of winter or in early spring, as the species is known to do off New Zealand (Phillipps and Hodgkinson, 1922, p. 94) and off South Africa (Gilchrist, 1916, p. 8).

After the conclusion of the third trawling survey, when the 'William Scoresby' was on passage to Europe, young *Thyrsites* were captured in the young fish trawl at St. WS 881. This station was worked in the area to the north-east of the Falkland Islands, which is periodically influenced by mixing of warmer water from the Brazil current to the north with sub-Antarctic water.

In the regions where *Thyrsites* is abundant (off South-West Africa and south-eastern Australia) nearly all are caught by trolling, jigging or other forms of line fishing. Very few have been taken in trawls. Our records cannot therefore be considered as conclusive evidence of its distribution. Nevertheless, they show a pattern in time and space so consistent with what is known of the habits of the species elsewhere, that it seems worth while to draw certain tentative conclusions from them.

It is believed that the part of the Patagonian Continental Shelf with which we are chiefly concerned provides a habitat too cold for *Thyrsites* throughout most of the year, and that such adults as were captured in the warmer inshore waters in autumn indicated the probable southern limits of the feeding migration of the species. The distribution of *Thyrsites* off South Africa and New Zealand shows that it favours warmer waters than the hakes (*Merluccius*) of these localities; but although its tolerance of cold seems less than that of *Merluccius*, its tolerance of heat seems similarly restricted, for *Thyrsites* does not penetrate so far up the east coast of South Africa, into the region of the warm Mozambique current, as does *Merluccius capensis*. Thus *Thyrsites* seems limited to cool southern subtropical (rarely sub-Antarctic) waters where the surface temperatures range from about 10 to about 20° C.; whereas species of *Merluccius* range from areas with surface temperatures below 8° C. to the tropical convergences (temperature about 23° C. at the surface). The difference in thermal tolerance may be more precisely expressed by the statement that the optimal range for *Merluccius* is centred lower than that for *Thyrsites*, but the total range of *Merluccius* is the wider. *Thyrsites* is much more exclusively pelagic in habit than are any of the *Merluccius* spp., which may be regarded as demersal fishes during the daylight hours, and whose distribution will thus be affected by the cooler subsurface temperatures to a much greater extent. For this reason I believe that *Thyrsites* will only be found to work southwards into our area close to the mainland coast, in the warmer counter-current of 'old shelf water', or right offshore, where the influence of the warm Brazil current sometimes extends to about 49° S. I do not think that the species would normally cross the colder portions of the Falkland current, and such few stragglers as occasionally reach the Falkland Islands themselves (Norman, 1937, p. 96) have probably come from the north-east.

T. atun is most excellent eating, with exceptionally firm white flesh of good flavour and (in due season) rather high fat content. In November 1933, when the 'Discovery II' was outward bound on her third commission, we paid a brief visit to Tristan da Cunha, and there secured a plentiful supply of these fine fish by somewhat novel methods. While lying at anchor in about 7 fm., near the edge of the kelp off the main landing place, the fish were observed 'hovering' round the gangway lights at night. Fishing for 'five-fingers', etc., had been proceeding all day, and the school of *Thyrsites* were doubtless (primarily) attracted by some of the resulting offal. A cargo-cluster was lowered over the side (the night being calm) and a few volunteers, fishing with variously improvised jigs (I found an artificial squid very killing), landed close upon three-quarters of a ton of the fish in about 3 hr. The fish were placed in the ship's cold-store as soon as we finished cleaning them next morning, and provided at least one course per day for all who cared for them until we reached New Zealand (and a copious supply of mullet) some 2½ months later. It is thus evident that when chilled soon after capture the keeping qualities of *Thyrsites* are excellent. It is preserved by smoking in Australia, and is both salted and smoked in South Africa. Very large quantities are eaten fresh in both these countries.

Since *Thyrsites* is one of the most valuable food fishes in the southern hemisphere, it would certainly merit further attention if any commercial fishery is developed near the area we surveyed, and a discussion of its importance in other regions therefore seems worth while. Any captured incidentally in trawling for more plentiful species would augment the value of the catch, and if the suggestion of an autumnal invasion of the warmer inshore waters should prove a constant feature, it might even be worth while to try trolling for it.

In South Africa *T. atun* (locally 'Snoek') is a very important fish. Returns for three years 1929–32 (von Bonde, 1934) show it second only to *Merluccius capensis* (stockfish, hake) in weight of landings and in their value. The quantities landed fluctuate much more violently than those of most of the other important fishes. This is partly explained by the fact that the majority of the snoek are taken by small line-fishing vessels whose activities are much more subject to the vagaries of the weather than are those of the trawlers, which operate from the best harbours, and take the majority of the other fishes. Of the fishes captured by the line-boats *Thyrsites* is by far the most important. Figures given for two recent years (Director of Fisheries, 1938, 1939) show that *Thyrsites* yielded 57 and 35% by weight, 52 and 46% by value, of the total landings by vessels other than trawlers at the Cape. As these figures include the valuable crawfish landings the importance of the snoek is even greater than it at first appears.[1] The annual catch of snoek at the Cape has varied from some four million to over nine million lb. weight, and between about £23,000 and £90,000 in value, over a long period between the two wars. The price has shown the usual tendency to inverse relationship with supply, but has maintained a slight superiority over the average for all fish in each individual year for which data are available.

Some of the main features of the biology of *T. atun* in South African seas are succinctly dealt with by Gilchrist (1914, 1916). They are especially abundant in the colder waters off the south-west coast of Africa in late summer and autumn (the peak usually in May). At these times they feed heavily, especially on 'sardines' (*Clupea sagax*) when available, and become notably fat. They are in full roe towards the end of winter and are found with ripe eggs, and in poor condition, in September (early spring). The seasonal variation in condition is evidently most marked, for Gilchrist has told us how the fishermen used to sign-on for the 'poor snoek' season on 17 September and how they had learnt to look for the first appearance of the 'fat snoek' about the middle of December. From then until winter (June) is the best period for the fishery. The relative scarcity of *Thyrsites* in winter and early spring (the spawning period) is attested by returns from all the countries where it is regularly fished. This is doubtless partly due to a slackening of feeding intensity, well known among most fishes when spawning, that will obviously tend to reduce catches of line-caught species; but some definite migration for spawning purposes may also be involved.

In Australia *T. atun* (locally 'barracouta') is nearly as important as it is in South Africa. The information concerning it has recently been summarized (anonymously) in *Fisheries Newsletter* (1944, vol. III, part 5, p. 2) and there have been previous interesting references to it in that most stimulating publication. *Thyrsites* ranks third in importance among the individual species of Australian food-fishes, the annual catch averaging some five million lb. weight over the period 1930–44. Large fluctuations in supply are experienced with consequent variations in price. Normally the fish fetch from 8*s.* to 15*s.* per box, but in 1941 the supply fell until the price reached an 'all-time high' of 3*s.* 10*d.* per fish (*Fisheries Newsletter*, 1941, vol. I, part 1, p. 10). Although there had been a steady decline since 1938 there was not thought to be any immediate fear of over-exploitation. Previous periodic scarcity of the species had been known, and there is some hint that it may recur with a seven or nine year cycle. It was also observed that the fish are much more difficult to catch, by the prevailing trolling or jig-stick methods, when their natural food is abundant. This was so in 1941, when it was observed that the boats frequently worked through large schools of barracouta, milling among the clupeoids with which they distend themselves, without catching any. This is thought to have been a subsidiary cause of the scarcity. If the tentative suggestion of a seven or nine year cycle of abundance in the Australian stocks of *Thyrsites* is substantiated, the 'couta' boats should be obtaining peak catches in 1945–6 and 1947–8.

Thyrsites is limited to the most southerly of Australian seas, about 90% of the catch being taken in Tasmania, and most of the remainder in Victoria. In New South Wales it is rare, and farther north it is apparently unknown. I have not been able to find any account of the occurrence of *Thyrsites* in south-western Australia, but it is reasonably certain that it is found there, for Australian writers add the isolated islands of St Paul in the southern Indian Ocean to the list of localities from which it has been recorded.[2]

In Victoria trolling with a crude development of the native lure, from auxiliary sailing boats of

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[1] In the same two years the total trawler landings were from nearly three times to nearly four times as great as those of the other vessels by weight, and from more than three times to nearly seven times as great in value.

[2] I have not yet traced the origin of this record, but have no doubts as to its validity, for I believe that the distribution of *Thyrsites atun* is continuous round the world in southern subtropical seas. Local stocks may, however, become distinguishable when more intensively studied, as they will need to be in the future.

20–45 ft., is the principal method of capturing *Thyrsites*. Fishing is chiefly performed under sail at speeds not exceeding 4 knots, after a school of the fish have been located. In Tasmania similar methods are employed, but rank second in importance to the 'jig-stick', by which the fish are swung directly inboard on to a fore-and-aft chute, after snatching at a lure trailed on a very short trace attached directly to the end of a flexible pole. This interesting method of fishing bears an obvious relation to trolling, and also to the methods employed in hooking tunny and albacore off the Californian coast. (Most of the operatives in this latter fishery were Japanese.) In *Fisheries Newsletter* (1942, vol. 1, part 2, p. 1) we are told that netting was being supplied to Port Fairy with the object of testing the possibilities of a gill-net method of capturing barracouta. The results of this experiment should be most instructive. Although the Australian fishery has hitherto operated exclusively upon the surface schools of *Thyrsites*, the occasional occurrence of the species in otter-trawlings, in areas far removed from those fished at present, has been noted. These catches were made in 60–70 fm., i.e. nearly twice the depths in which we occasionally trawled the species off Patagonia.

Spawning of *Thyrsites* may take place to the north and east of Tasmania. This is certainly a nursery ground for young fry up to 3 in. in length, which have been abundantly found in stomachs of various large predaceous fishes (including adult *Thyrsites*) taken in this area. Young *Thyrsites* of 10–12 in. (? I or II-group) have also been observed not far away.

In Australian waters *Thyrsites* are often heavily infested with muscle-worms (? nematodes), and these may possibly be one cause of the emaciation that leads to afflicted fish being described as 'axe-handles'. I should be inclined to suspect the extreme seasonal fluctuation in condition, so well known in South Africa, as the main factor, for repeated attempts to correlate parasitic infection with loss of condition in numerous species of fishes have broken down when strict tests are applied. A disease of *Thyrsites* known as 'milkiness', due to protozoan infection, presents a more serious problem, and is now causing some concern in Australia. In New Zealand it is stated that *Thyrsites* occurring in northern waters are much subject to disease (Phillipps, 1921, p. 118). Now the fish are less common in the north, but the whole stock will tend to move northwards in winter, and, moreover, they are believed to spawn even earlier off New Zealand than they do off South Africa (August rather than September: Phillips and Hodgkinson, 1922, p. 94). Hence it is probable that natural seasonal loss of condition is at least partly responsible for reports of disease.

In the New Zealand fisheries 'barracouta' are not so important as in Australia and South Africa, doubtless owing to the good supply of *Jordanidia solandri* ('southern kingfish', 'hake'!). Comparable figures for the whole country are not available, but separate returns for *Thyrsites atun* have been made at a few of the individual ports. Wellington shows the highest of these returns, and from the Fisheries Reports of the Marine Department it can be seen that *Thyrsites* formed from 2 to 4% of the total catch here over several years between 1931 and 1938. During the best years this figure represents over 1000 cwt.

The common names applied to *Thyrsites* are used for other fishes so promiscuously as to lead to the possibility of endless confusion to anyone not personally acquainted with these other fishes as well, so I have thought it best to treat this matter in detail:

T. atun (Euphrasen), a gempylid, has three main vernacular names in different parts of its wide range, that extends round the world in the cooler parts of the southern sub-Tropical Zone. These are **snoek** (from the Dutch word first applied to the European fresh-water pike, *Esox lucius*) in South Africa excepting Natal; '**barracouta**' (from barracuda, first applied to the marine Sphyraenidae in Europe and the West Indies) in Australia and New Zealand; and **sierra** (from Spanish, lit. a saw, applied chiefly to 'king-' or 'spanish-mackerels' elsewhere) in Chile. These names are all descriptive: **snoek** relating to the superficial resemblance between body-form and pointed, formidably toothed, jaws of *Esox* and those of *Thyrsites*; **barracouta** relating to a similar resemblance between the marine Sphyraenidae and *Thyrsites*; and **sierra** presumably referring to the rows of spiny finlets between the posterior median fins and the caudal of *Thyrsites*.

The first objection to widespread use of these names is already clear: they are applied to other fishes elsewhere, many of which bear no close relationship to *Thyrsites*. But there are two other equally important objections. First, some of the other fishes showing such overlapping of common names may inhabit the same areas as *Thyrsites*; this is especially true of Australian seas. Secondly, these other fish have themselves been given a further range of vernacular names, which again overlap, and increase the possibility of confusion twice confounded with yet other fishes (or groups of fish).

In Natal 'snoek' refers to *Scomberomorus commersoni* (Cuvier and Valenciennes) (Scombridae: Gilchrist, 1914, p. 118) which is the 'narrow-barred spanish-mackerel' of Australia, and is also known as 'kingfish', 'king-mackerel' and even (in western Australia) as 'albacore' (Munro, 1943, p. 74). In Puerto Rico (West Indies) 'snook' refers to *Centropomus parallelus* Poey, the 'robalo' (Jarvis, 1932, p. 4). The Centropomidae are a percoid family closely allied to the Serranidae. In Australia, on the other hand, 'snook' sometimes refers to the 'short-finned pike', *Sphyraena novaehollandiae* Günther, which a European or an American would call a 'true' barracuda (Waite, 1921, p. 85).

Barracuda or 'barracouta' refer to Sphyraenidae in Europe, the West Indies, North America and South Africa, and it was to this group of fishes that the name was first applied. But this group is also represented in Australia and New Zealand and other haunts of *Thyrsites*, where they are known as 'pikes' or 'sea-pikes', with or without such specific qualifications as 'short-finned' (*Sphyraena novaehollandiae* Günther (Waite, 1899, p. 132)), and also, more rarely, as 'snook'. According to Evermann and Radcliffe (1917, p. 51) *Sphyraena idiastes* Heller and Snodgrass is known as 'aguja' (Spanish, lit. a needle or bodkin) in Peru. This name is applied to a very wide variety of slender fishes, including 'pipe-fishes', in various parts of the world.

The original ichthyological connotation of 'sierra' in Spain seems to have been *Pristis* sp., a 'saw-fish', one of the elasmobranchs! The name is also applied to various *Scomberomorus* spp. ('king-' or 'spanish-mackerels', Scombridae) in Spanish-speaking parts of the Americas north of the range of *Thyrsites*.

Let us consider only two examples of the secondary complications that can arise among the common names applied to fishes which share the main vernacular appellations of *Thyrsites*:

The 'king-' or 'spanish-mackerels', *Scomberomorus* spp., Scombridae, are often referred to as 'kingfish'. This name is also extensively used for certain Gempylidae other than *Thyrsites*, notably for *Jordanidia* (*Rexea*) *solandri* (Cuvier and Valenciennes) in Tasmania and New Zealand. This fish is in its turn sometimes called 'hake' in New Zealand, even though there is a 'true' hake, *Merluccius australis* (Hutton), on the spot. 'Kingfish' is also (rarely) applied to the 'king-whiting' (*Menticirrhus* spp., Sciaenidae) in parts of the United States.

'Pike' is applied in the Falkland Islands to *Champsocephalus esox* (Chaenichthyidae, Notothenii-formes), and in Australia and New Zealand to the Sphyraenidae. In Australia also 'long-finned pike' refers to *Dinolestes lewini* Griffith (Waite, 1921, p. 99). This is one of the Apogonidae, a family equally remote from the Sphyraenidae and the Gempylidae.

SCOMBRIDAE

Gasterochisma melampus Richardson. Norman (1937, p. 97) has shown that although we did not obtain any specimens of this interesting oceanic species during the trawling surveys, there is evidence of three specimens reaching the Falkland Islands. Some portions of a damaged skeleton from West Point Island were secured by Dr J. E. Hamilton. Norman adds an interesting note recording his opinion that one species hitherto considered as distinct, and two others previously described in different genera, are but growth stages of *G. melampus*, and quotes close parallels in yet other genera. Such difficulties are bound to occur with rare species known from very few specimens, and can only be rectified as larger series are collected.

ZOARCIDAE

Ophthalmolycus macrops (Günther). We took no specimens of this species, which is known only from the holotype obtained by H.M.S. 'Challenger', in the Magellan Strait.

Iluocoetes fimbriatus Jenyns. This was the commonest member of the family captured during the trawling surveys. It was found to attain considerable size (more than 40 cm. long), and was found mostly in moderately deep water near the outer margin of the shelf, and more rarely beyond the shelf edge, down to the greatest depths fished. It was found in all three regions within the area, with perhaps a tendency to be most numerous in the intermediate region:

WS71	1	*WS244*	2	*WS812I*	1
WS92	1	*WS246*	1	*WS821*	1
WS98	1	**WS765**	1	*WS825*	1
WS99	1	WS784	6	**WS855**	1
WS210	5	**WS792 B**	1		
WS212	2	WS795	1	*51*	4 (in OTL)
WS214	1	WS801	1	**WS856**	1 (in BTS)
WS216	5	WS809	1	*WS869*	1 (in BTS)
WS218	1	*WS811 II*	1	*WS829*	1 (in NR)

The spotted brown and white colour pattern so well shown by E. R. Gunther's sketch (Norman, 1937, pl. i, fig. 4) suggests concealment value among the bracken-like forests of coralline hydroids and Polyzoa frequented by the species. The sketch also shows how in its general appearance, the beast without background is extraordinarily reminiscent of a wet hen. *I. fimbriatus* is known to range as far as southern Chile, outside our area.

Iluocoetes elongatus (Smitt). This species was taken three times only, once in the trawl and twice with 'Other gear', in shallow water ('first slope') in the southern region. The colour pattern is exceptionally variable but is always barred rather than spotted, and the species may always be distinguished from the last named by the entire absence of scales (*I. fimbriatus* has small scales embedded in the skin):

WS834	6	*WS835*	14 (in BTS)	*WS749*	17 (in NR)

Austrolycus depressiceps Regan. No specimens of this littoral southern species were secured during trawling operations, but series for Norman's report were readily obtained from East Falkland (Mr A. G. Bennett) and West Falkland (Dr J. E. Hamilton). The species extends to the Chonos Archipelago (between 46 and 44° S) on the west coast of southern Chile, outside our area. One of Bennett's specimens was 48 cm. long, and he tells us that the species has been known to attain a weight of 3 lb. at the Falkland Islands, where they are sometimes known as 'rock-eels'.

New Island	6 (J. E. H. *coll.*)	Port Stanley	13 (A. G. B. *coll.*)

Austrolycus laticinctus (Berg). We obtained four small specimens of this species in the rectangular net at a single station in the southern region. From Norman's account (1937, p. 104) it appears that the synonymy has been much confused, and that it may be found to range much farther up the mainland coast than most of the Zoarcids with which we have to deal:

WS749 4 (in NR)

Phucocoetes latitans Jenyns. A few specimens of this tiny species were obtained at two southern stations in shallow water, and others were collected by Bennett from kelp holdfasts in Stanley harbour.

This appears to be the normal habitat of the species (Norman, 1937, p. 105), and the brown and yellow coloration would there have 'concealment value'. Ripe ova were present in two specimens taken at St. WS847 in February; this suggests autumn spawning, and shows that the species really is very small, for none more than 14 cm. long was taken, and yet two of these were mature:

WS847B	4	*WS749*	2 (in NR)	Port Stanley	4 (A. G. B. *coll.*)

Crossostomus chilensis (Regan). We got no specimens of this species which, despite its name, is known only from the holotype taken off the *east* coast of Tierra del Fuego.

Crossostomus fasciatus (Lönnberg) is only known from the holotype, taken at the Falkland Islands. Norman (1937, p. 106) thought that it may really have been a young example of *Austrolycus depressiceps*.

Pogonolycus elegans Norman. Five examples of this new species were obtained at four stations ranging in depth from the 'first slope' to beyond the shelf edge. Three of these were in the southern region, the other in the intermediate region. The colour sketch by E. R. Gunther (Norman, 1937, pl. i, fig. 3) shows a pattern that probably has concealment value among the heavy sessile invertebrate bottom fauna with which it was found. It was especially noted that its appearance coincided with large catches of *Cephalodiscus* colonies:

WS97	1	*WS749*	1 (in NR)
WS246	1	*WS878*	2 (in NR)

Platea insignis Steindachner. No specimens of this species were taken in the trawl, but a series was obtained with 'Other gear' from two southern stations worked in shallow water. The colour scheme is of the basic type so characteristic of most of the group in our area, consisting of more or less regularly disposed bars, blotches or spots, contrasting in shade with the ground colour. In this species it is the ground colour which is the paler:

WS749	6	WS835	8 (in BTS, haul B)

Maynea patagonica Cunningham. No specimens of this small, rare, probably coastal species were obtained by us, but it is known to occur within the trawling survey area (Norman, 1937, p. 108).

Maynea brevis Norman. Four specimens of this new species were taken in the trawl, two in the intermediate region and two farther south. Three were in moderately deep water near the edge of the shelf, and one in deeper water beyond the edge. This last was the largest specimen (length 16 cm.). Norman notes that it may eventually prove necessary to place this species in a distinct genus, and that its dentition approaches that found in the genus *Melanostigma*:

WS216	1	WS784	1
WS244	1	*WS825*	1

Melanostigma gelatinosum Günther. This species is known only from the unique holotype taken in the Magellan Strait; it may yet be found more widely distributed in our area.

Melanostigma microphthalmus Norman. Two specimens of this new species were trawled, both in deep water south of the Falkland Islands:

WS246	1	*WS248*	1

SUMMARY OF OBSERVATIONS ON ZOARCIDAE

The eel-like shape and small size of most of the members of this family render it certain that they cannot be adequately sampled by ordinary trawling. Moreover, many of the species are littoral in habit, while those dwelling at greater depths seem to favour very rough ground, with the dense sessile fauna of corraline hydroids and Polyzoa that E. R. Gunther aptly likened to bracken. In such conditions all types of collecting gear have their efficiency much reduced. Nevertheless, I believe that the group really are comparatively scarce and unimportant ecologically, as our scanty collections would seem to imply, for a very comprehensive series of hauls with several types of 'Other gear' was carried out, and the 'William Scoresby' was more successful in capturing Zoarcidae than any previous expedition to the area had been. Of the total of fourteen species now known from the region, specimens of nine were obtained; and of the five missed, three are known only from their unique holotypes, while a fourth is still a doubtful species.

Two of the species living in deeper water, *Maynea brevis* and *Melanostigma microphthalmus*, were taken only in the 'Trawl + accessory nets'. Three probably littoral species were obtained only with 'Other gear', *Austrolycus depressiceps*, *A. laticinctus* and *Platea insignis*. The remainder, taken with both main types of gear, showed a wider depth distribution, the deeper dwelling larger species (notably *Iluocoetes fimbriatus*, the commonest in our collections) being relatively more numerous in the trawl as one would expect. Only *I. fimbriatus* and possibly *Austrolycus laticinctus* extended to the northern region of our area, and the group as a whole were definitely most numerous to the south.

The Patagonian Zoarcidae seem broadly divisible into shallow-water or littoral species, and deep-water species, thus:

Shallow-water or littoral species: *Iluocoetes elongatus*, *Austrolycus depressiceps*, *A. laticinctus*, *Phucocoetes latitans* and *Platea insignis*.

Deep-water species: *Iluocoetes fimbriatus*, *Pogonolycus elegans*, *Maynea brevis* and *Melanostigma microphthalmus*.

Of the latter only *Pogonolycus elegans* has shown a single small specimen in shallow water, while most were taken quite deep down. It is also noteworthy that the deep-water species showed a strong tendency to occur on the deepest portions of the shelf near its south-eastern boundary (and beyond). They were not found at the slightly lesser depths of the level plain of the shelf that covers such a large proportion of the area surveyed. It is not possible to consider this depth distribution in detail on the basis of such small numbers of zoarcids as were obtained, but there is some indication that it will eventually be found to be correlated with the distribution of certain types of sessile benthic fauna. The markedly 'patterned' colour schemes so prevalent throughout the group, with bars and stripes, or spots and blotches of contrasted shades, and often with brown and yellow or white tints, even upon the upper surface of the body, strongly suggest that camouflage is a necessity among them; and just as the shallow-water species (e.g. *Phucocoetes latitans*) are known to frequent kelp, so is it probable that the deep-water species find their optimum on the rough ground with bracken-like fauna of coralline hydroids and Polyzoa, known to prevail over some of the deeper parts of the shelf.

The large variety of species in this group is one of the peculiar features of the Patagonian fish fauna, as already explained, but it does not seem likely that they are sufficiently abundant to play an important part in the ecology of the region.

LYCODAPODIDAE

Norman (1937, p. 110) has pointed out that it is not yet certain whether this family can be maintained as distinct from the closely allied Zoarcidae.

Lycodapus australis Norman. We obtained four specimens of this new species at a single haul of the rectangular net at St. *WS748*, in one of the deepest parts of the Magellan Strait. Its occurrence is of particular interest, for all previously known members of the genus hail from the Pacific coast of North America, and we have already seen that there are other resemblances between the fish fauna of that region and that found off Patagonia.

OPHIDIIDAE

Genypterus blacodes (Schneider). This species is also found in New Zealand and Tasmania, where it is known as 'ling', and in southern Australia where it is sometimes called 'rockling'. In New Zealand (and to a lesser extent in Tasmania) it is esteemed for the table, and considerable quantities are marketed. It is too rare off southern Australia to attract much attention from professional fishermen. We learn from Norman (1937, p. 112) that off Patagonia *G. blacodes* goes by the Spanish name 'abadejo'. In Spain this word is often loosely applied to cod, but dictionaries state that it is more strictly applicable to pollack. Two allied species of *Genypterus* known only from the west coast of South America are given the names 'congrio...' with suitable adjectival qualifications. All the species of *Genypterus* are very similar in form, bearing a strong superficial resemblance to a true conger, so that this vernacular distinction of *G. blacodes* in South America, where it is known from both east and west coasts, argues close observation on the part of the local fishermen.

A very closely allied form, *G. capensis*, may yet prove specifically identical with *G. blacodes* (cf. Norman, 1937, p. 113). *G. capensis*, known as 'king-klip', is an important fish in South Africa. Most of them are obtained by trawling in rather deep water, and although they form only about 2% by weight of the total landings, they fetch prices considerably above the average. Thus they represented 2·9–4·5% of the value of the fish landed during three years 1929–32, and the sums realized at first sale ranged from £11,000 to just over £20,000 (S.A.). Evidently the edible qualities of the genus are appreciated wherever they are to be found, but they cannot be a cheap fish to catch, for they are not much given to shoaling. Numerous trawling records off South Africa (von Bonde, 1934, pp. 42–63) show 'king-klip' in consistently small numbers where they occurred at all, though large catches of shoaling species like *Merluccius capensis* were being made.

In the area of the trawling surveys *Genypterus blacodes* was taken in very small numbers throughout the year, but the data are far too scanty to permit of any detailed consideration of the bionomics of the species. The distributional data are, however, very interesting and sufficient to suggest two main trends of movement, supporting the view that most of the *G. blacodes* taken in the area are seasonal southern stragglers from a stock inhabiting warmer waters, farther to the north. The records are:

WS78	3	WS783	1	*WS811 II*	3
WS79	3	WS785A	1	*WS812 II*	1
WS95	1	**WS789**	3	*WS816*	1
WS98	1	**WS792A**	1	*WS817A*	1
WS108	1	**WS792B**	1	*WS819B*	1
WS214	2	WS794	3	*WS848*	1
WS216	5	WS795	6 seen to escape		
WS217	4	WS797B	1	*WS870*	1
WS218	13	WS809A	1	*WS875*	2
WS772	1	WS810	2		
WS773	4	*WS811 I*	1	WS586	3 (on LH)
WS776	1			Connor inlet	1 (on LH)

It can be seen that apart from four specimens caught on hand-lines in the western channels, outside the area of the trawling survey, all the specimens were taken in the trawl.

In Fig. 43 the records are shown on three seasonal charts with a schematic representation of the trends of movement they are believed to indicate. In winter and spring (*a*) the species seemed to be confined to a small area of deep water near the edge of the shelf, and near the northern boundary assigned to our intermediate region. In summer (*b*) the records suggest that these fish tended to move into slightly shallower water, and also southwards. At the same time it seemed that other *Genypterus blacodes* invaded the area from the north, working south along the 80 m. line in the relatively warm inshore counter-current. Where this current peters out, in the northern part of our

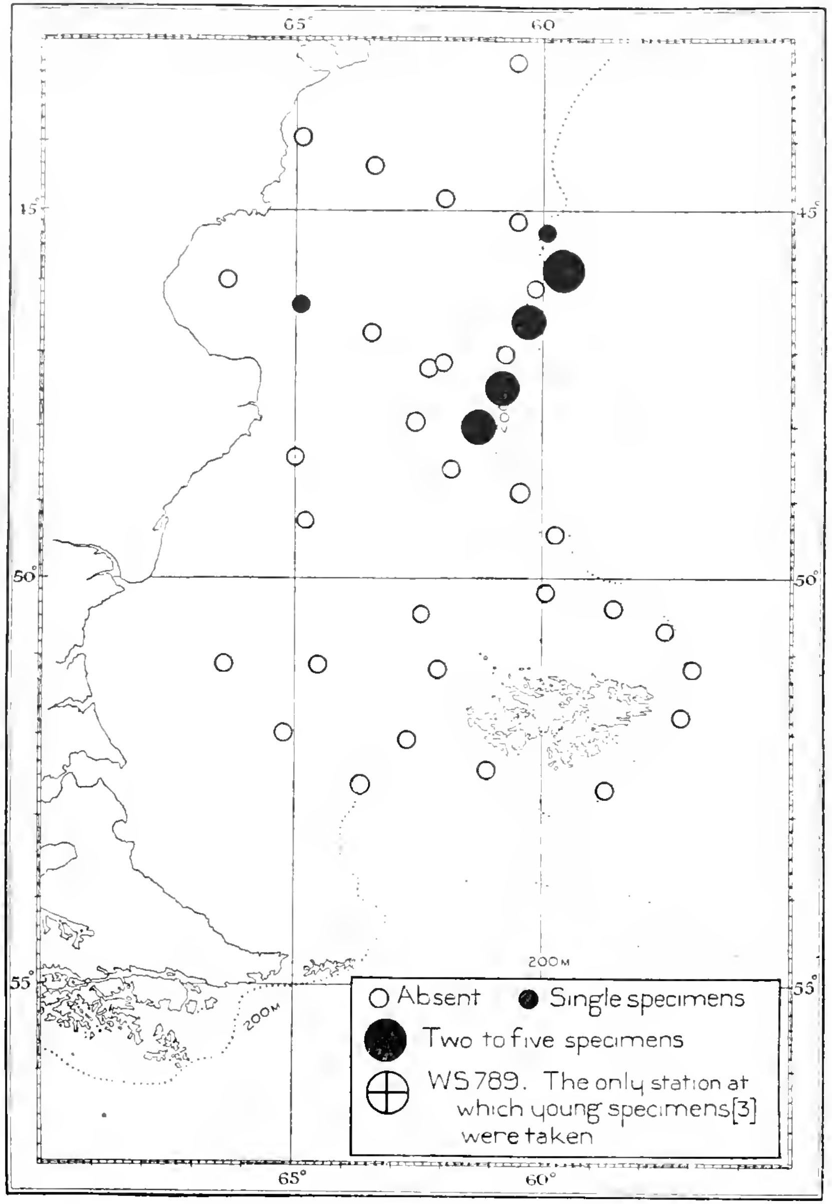

Fig. 43*a*. Distribution of *Genypterus blacodes*. Winter and spring.

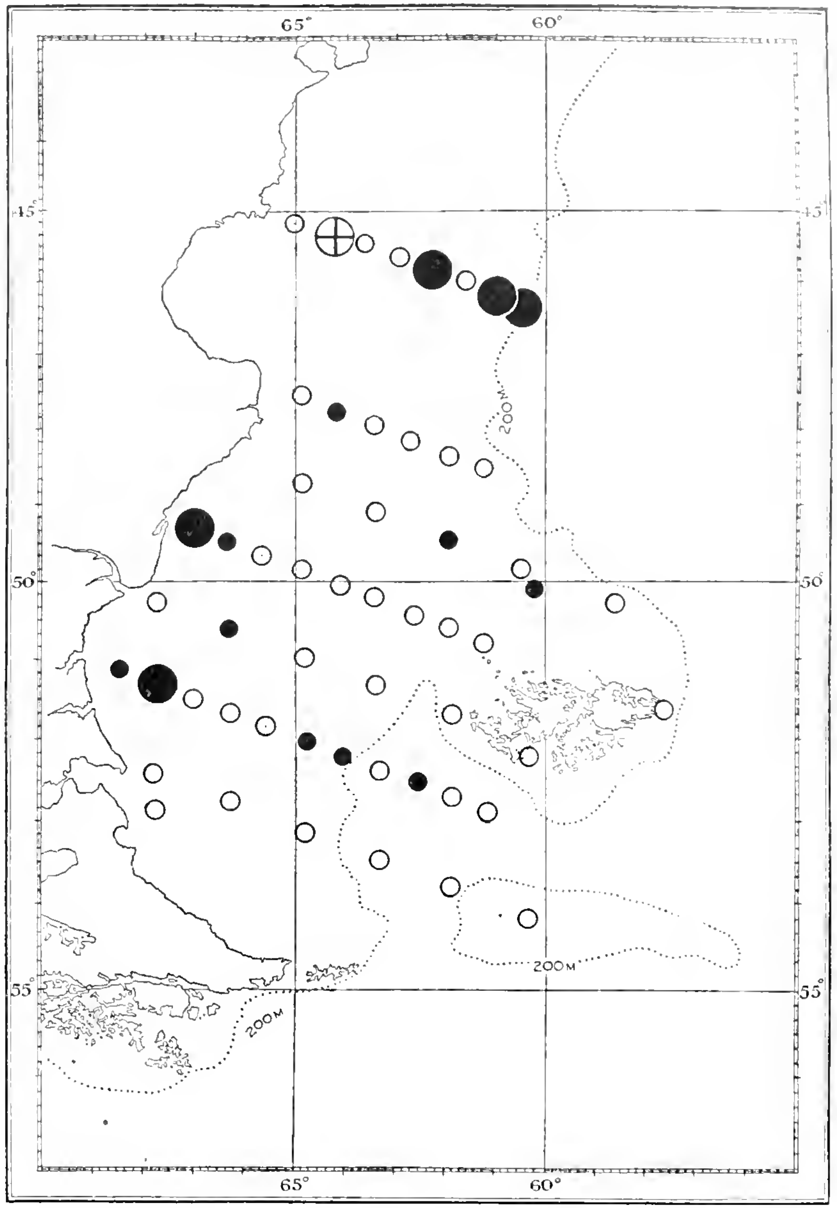

Fig. 43*b*. Distribution of *Genypterus blacodes*. Summer.

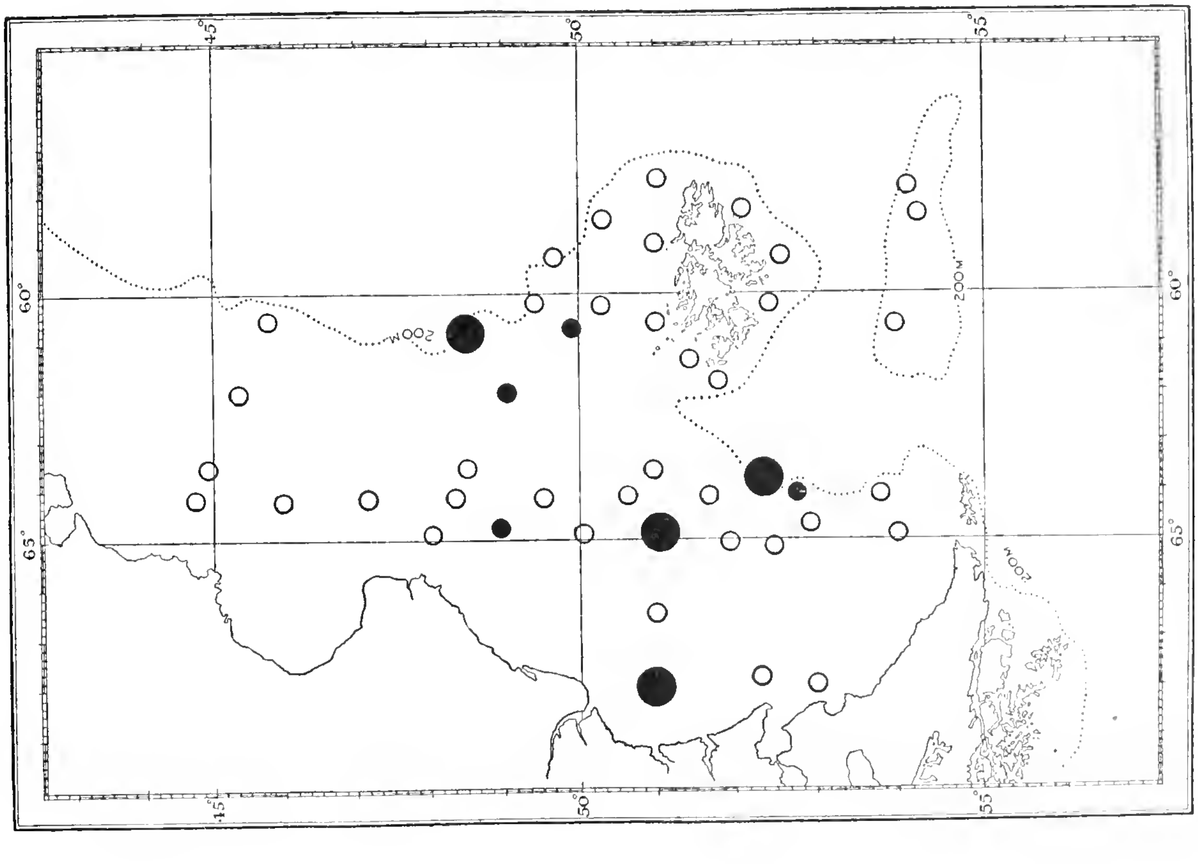

Fig. 43*c*. Distribution of *Genypterus blacodes*. Autumn.

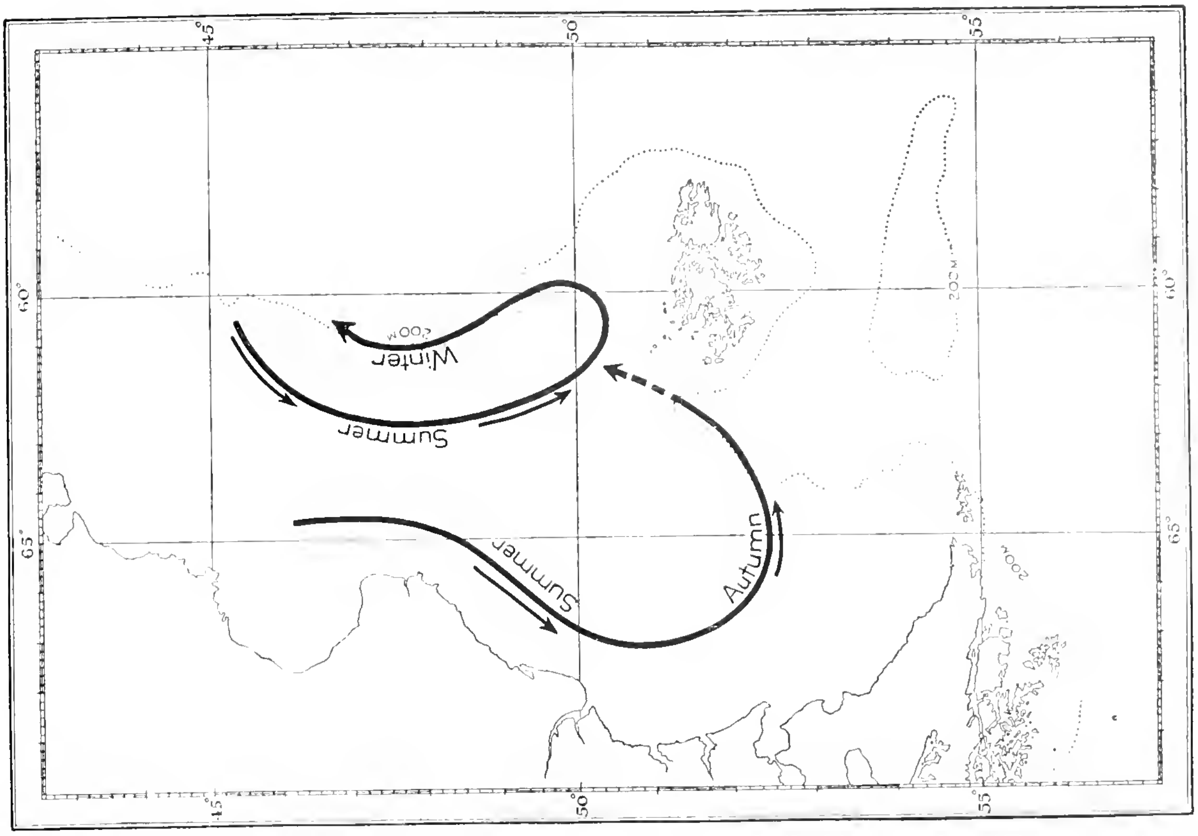

Fig. 43*d*. Distribution of *Genypterus blacodes*. Apparent seasonal movements.

southern region, there was in late summer a strong indication of offshore movement, that continued into autumn (*c*) as one would expect if *Genypterus* moves offshore in winter like so many other demersal fishes.

The measurements—too few for detailed consideration—show extremes of size in the north, while individuals caught in the south were more uniform. Possibly the southward movement down the coast and out again is mainly confined to adolescent individuals. Really small young individuals were taken at one northern station only.

The interesting point that seems fairly certain from the distribution observed is that *Genypterus* seemed to avoid the central plain of the shelf, being found mainly along the lines of steepest gradient, i.e. the 'first slope' inshore, and the edge of the shelf to the north. Our only captures of the species on the central plain were near its southern limits in autumn, when those that have worked down the coast are believed to be seeking deeper water. This they seemed to succeed in reaching in the deeper southern portion of the Falkland trough, and since they have not been seen at any of the numerous stations worked in the immediate neighbourhood of the Falkland Islands I conclude that if they further succeed in regaining a more normal, northern habitat, it is by way of the Falkland trough that they do so, as indicated by the dotted portion of the line on the diagram (Fig. 43 *d*).

BROTULIDAE

Cataetyx messieri (Günther). Two small specimens of this rare fish were taken in deep water beyond the edge of the shelf, one in the intermediate region and one farther south. It has also been recorded from Messier Channel, Chile, and South Africa. A specimen 63 cm. long has been taken in very deep water off Cape Point. E. R. Gunther considered that the normal habitat of the species lies below the depth limit of ordinary trawling:

WS248 1 WS773 1

CENTROLOPHIDAE

Seriolella porosa Guichenot. This species was only captured at a single northern inshore station, WS853 (8), worked early in autumn. The French found it common in Orange Bay, near the eastern end of the Magellan Strait in 1883 (Vaillant, 1888, p. C30), and it might therefore be expected to occur throughout the length of the shelf. Endeavouring to explain our lack of evidence of such extended distribution, E. R. Gunther noted that its shape and colouring suggest fast swimming near the surface, which might help to account for its being missed by the trawl. Alternatively, it may be a strictly coastal species rarely moving offshore so far as the main trawling grounds.

The species is also known from New Zealand, and from Tasmania, where *Neptonemus dobula* Günther was the synonym used by Johnston (1891), and *Seriolella doubla*[1] Günther the synonym used by Lord (1923, p. 66). These writers tell us that it is known as 'trevally' or 'mackerel-trevally' in Tasmania. The closely allied *Seriolella brama* Günther, the 'snotgall' or 'snotgall-trevally' of Tasmania, is also sold under the name of 'trevally' in Christchurch and Dunedin, New Zealand, but in that country the name is more usually (and correctly) applied to *Caranx platessa* Cuvier and Valenciennes. It is also noteworthy that in Tasmania a true carangid (*C. georgianus*, Cuvier and Valenciennes) is called 'silver-trevally' (Lord, 1923, p. 67), while the usual New Zealand name for *Seriolella* is 'silverfish', which can of course lead to immediate confusion with atherines in that and most other countries.

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[1] A misprint.

The etymology of the name 'trevally' is exceedingly interesting. It appears to be derived from the Portuguese *cavalha*, a horse or horse-mackerel (spanish *caballa*), names which are still applied to *Caranx* in their countries of origin. In the Gulf of Mexico and eastern Florida this name applies to *Caranx hippos* (Linnaeus) but has become corrupted to 'cavally', and even to 'Horse crevallé'[1] in South Carolina. As a further complication on the ichthyological side, 'crevallé' is sometimes applied to *Trachynotus carolinus* (Linnaeus), although this species is widely known as the 'common pompano' in the eastern states. I suggest that 'crevallé' became readily corrupted to 'trevally' and, as applied somewhat loosely to carangid or closely allied fishes, reached the southern hemisphere with the New England whalers and sealers early in the last century. Whether the final corruption took place *en route* or after arrival must remain a matter for speculation.

Palinurichthys coeruleus (Guichenot). Norman (1937, pp. 116–18) tentatively refers both this and the next species to the genus *Palinurichthys*, remarking that the genera of Centrolophidae need revision. It was with some doubt that Norman identified our two specimens from the centre of the shelf with Guichenot's *Seriolella coerulea* from Juan Fernandez off the west coast, owing to vagueness of the original description:

WS97 1 *WS816* 1

Palinurichthys griseolineatus Norman. Our specimens of this new species, which would seem to be rare, all came from the centre of the shelf. I have found a note of E. R. Gunther's which states that: 'Its colour in life is of a delicate blueish and silvery gray: the gray running along the sides in horizontal undulating bands which divide and merge. The reference by Norman (1937, p. 117) to brownish and yellow has doubtless resulted from staining by teak and alcohol used in storage and transport.'

WS75 1 WS97 1 WS108 1

STROMATEIDAE

Stromateus maculatus Cuvier and Valenciennes. This fish is more likely to become of value as food for man than most of the others found within the area of the trawling surveys. Its flesh is rich and well flavoured (other members of the family being also noted for their pleasant taste, and the high fat and mineral content of their flesh) and free from too many small bones. In South America, where Norman (1937, p. 118) tells us that it is called 'pampanito', the species seems to have acquired an undeserved reputation for causing gastric disorders when eaten, and some hint of this prejudice may be found in the Falkland Islands.[2] The crew of the 'William Scoresby' ate *Stromateus* with relish and without any ill effects, and from what is known of closely allied species that have long been exploited on a large scale in the eastern U.S.A. and in China, I have no doubt that its ill repute is due merely to more rapid decomposition (when stored too long under primitive conditions) than species of lower food value. There seems to be no English vernacular name for this fish, and I would venture to suggest 'spotted pomfret' as most suitable; alternatives based on other common names applied to members of the family elsewhere would probably leave more scope for confusion, as will be shown later.

Stromateus ranked third in total weight of the fishes captured during the third survey, and fifth in total numbers during all three surveys. Although of uniformly small size they are nearly all potentially saleable, owing to their compact bream-like shape. They commonly range from 10 to 13 in. (25–34 cm.) in length, and from 7 oz. to 1 lb. (200–470 g.) in weight. A very high proportion of the fish (almost certainly over 60%) is edible. Analysis of the closely allied Chinese species *Pampus* (*Stromateoides*) *argenteus* (Euphrasen) shows 64% edible (Read, 1939, p. 45). Our largest specimens of *Stromateus maculatus* measured 38 cm.

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[1] Truly a work of supererogation!

[2] *Stromateus*, however, seems rarely to penetrate to the immediate vicinity of the Falklands: we took them at four only of the many stations worked within 100 miles of the islands, and the nearest was 75 miles away.

Although we took only about a thousand of this species during the three surveys, we have strong evidence that many more large hauls of it could have been obtained in summer (when it tends to shoal inshore), had we been concentrating upon it as a commercial fishing vessel would have been able to do, instead of sampling the whole area.

During the three trawling surveys, *S. maculatus* was captured in the 'Trawl + accessory nets' at fifty-two stations, as shown below. It was never taken by us with 'Other gear':[1]

WS78	20	**WS792B**	13	*WS817A*	4
WS97	8	WS794	2	*WS817B*	2
WS108	22	WS797B	2	*WS833*	203
WS214	1	WS797C	8	*WS838*	2
WS217	4	WS798	10	*WS847A*	146
WS762A	9	WS799B	6	*WS847B*	100
WS763	1	WS800A	32	*WS848*	27
WS764B	4	WS800B	7	*WS849*	26
WS771	2	*WS806*	1	*WS850*	2
WS784	4	WS809B	92	**WS853**	3
WS785A	6	WS810	3	**WS858**	1
WS785B	7	*WS811I*	21	**WS859B**	1
WS786	3	*WS811II*	58	WS862	1
WS788B	1	*WS812I*	19	WS864	5
WS790A	14	*WS812II*	40	WS866	18
WS790B	19	*WS813*	52	WS868	1
WS791A	1	*WS814*	1		
WS791B	7	*WS815*	2		

The distribution of these catches at different seasons of the year is charted in Fig. 44. From this it can be seen that in spring (*a*) a few *Stromateus* were taken on the shelf in the northern region, and that there a few were already right inshore. The species was not observed on the single line of stations worked in the intermediate region, nor at a couple of odd stations worked farther south at that season. From this it may be concluded that in spring some shoreward movement has begun, but probably little southward movement.

In summer (*b*) the species was much more frequently taken and in very much larger numbers, especially to the southward. Several really good hauls of *Stromateus* were made inshore, from Cape Virgins northwards to a point off Puerto san Julian. Moderate numbers were taken at several stations on the plain of the shelf, but the species was not taken in the deeper water to the southward. It was also absent from all but one of the catches at the outermost stations (those worked nearest to the shelf-edge) on the northern and intermediate lines, and from the immediate vicinity of the Falkland Islands. It would seem clear that the species works southwards inshore during summer, and reaches maximum concentration (shoaling) at that season.

In autumn (*c*) some *Stromateus* were caught still inshore in Grande Bay in the southern region, but this was in only one of the two years for which we have autumn data, and the location of most of the catch was farther offshore (though still on the plain of the shelf) and to the north. The distribution is clearly compatible with the hypothesis of dispersal of the southern summer inshore shoals in that direction.

Stromateus was captured at two stations only during the winter survey (*d*). These were right offshore on the shelf edge in the intermediate region, and the numbers of individuals were but one and four respectively. None was taken at any of the numerous stations worked on the plain of the shelf and to the southward at this season. These observations clearly point to continued dispersal offshore and to the north.

Perhaps the 'spotted pomfret' should be regarded as a semi-pelagic wanderer in winter. Its seasonal

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[1] Cf. Goode's remark of *Poronotus triacanthus*: 'it has never been known to take a hook.' Quite recently, however, some line-caught *Poronotus* were reported from Florida.

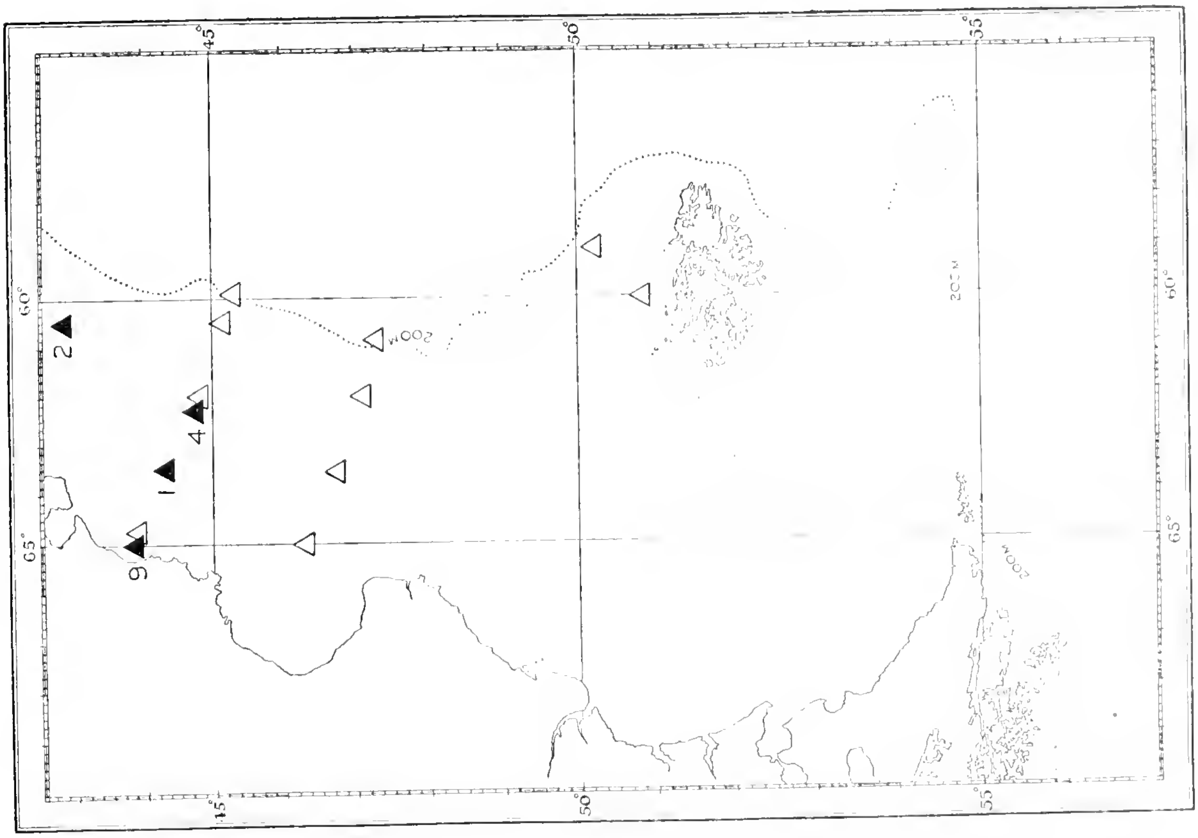

Fig. 44*a*. Seasonal distribution of *Stromateus maculatus*. Spring.

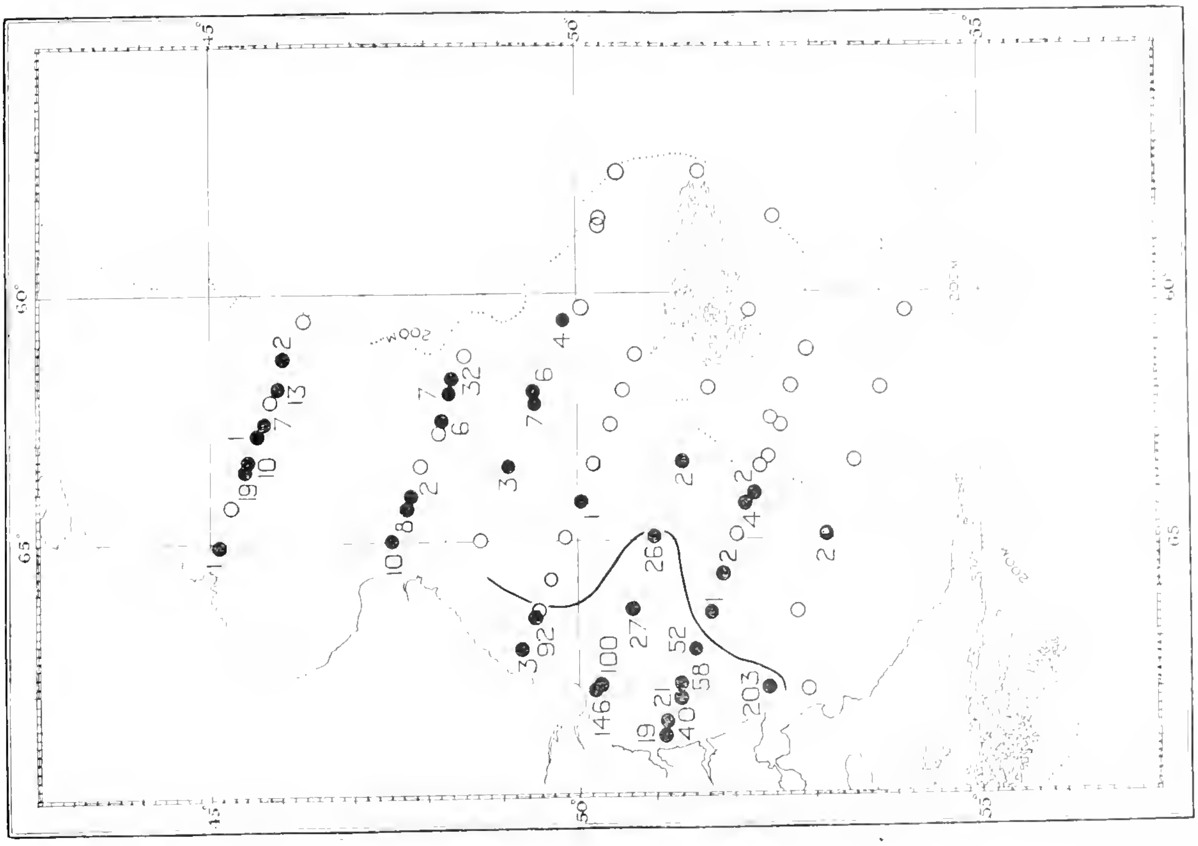

Fig. 44*b*. Seasonal distribution of *Stromateus maculatus*. Summer.

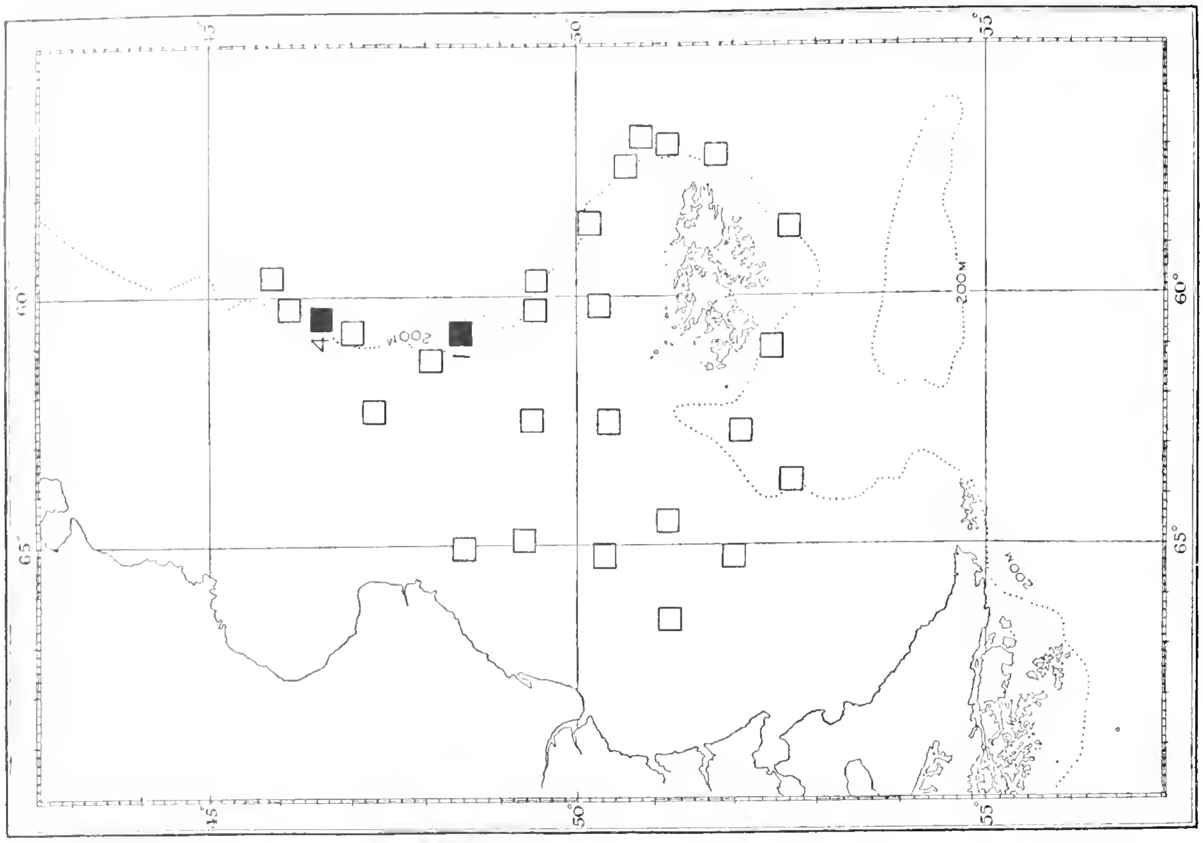

Fig. 44*d*. Seasonal distribution of *Stromateus maculatus*. Winter.

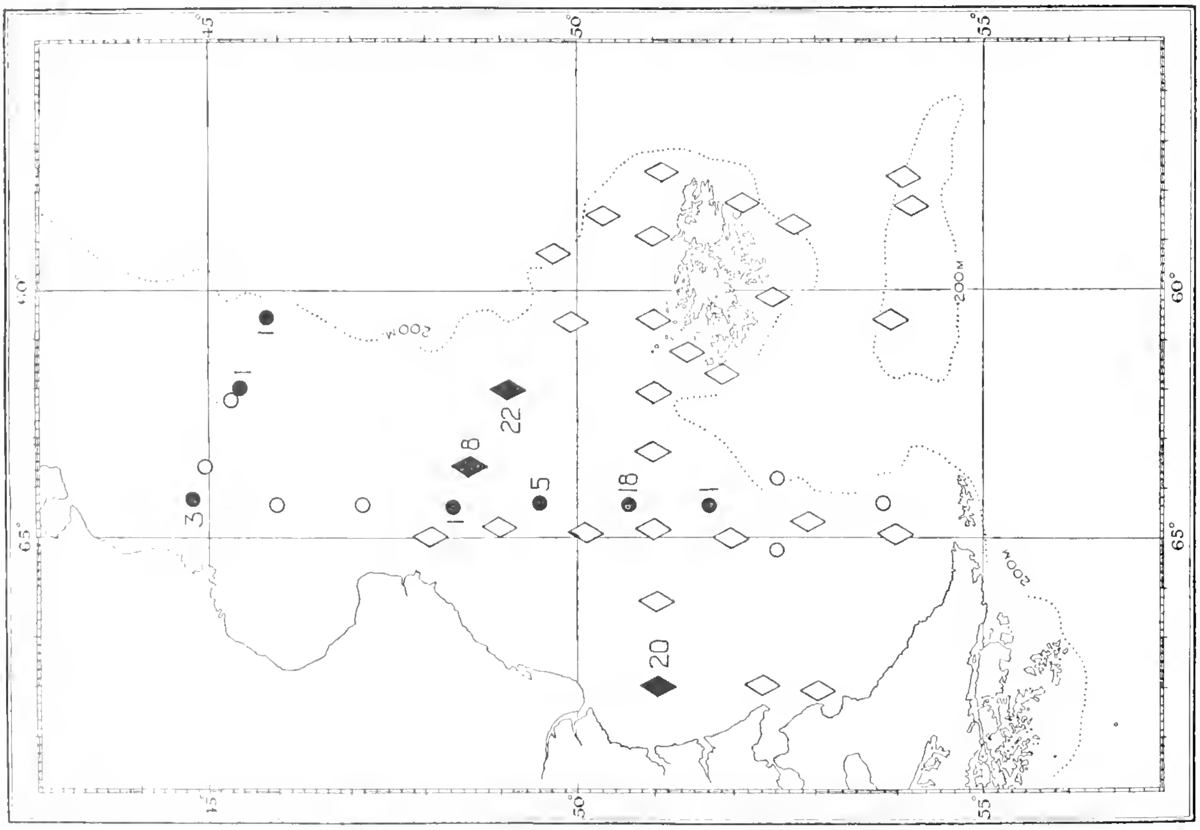

Fig. 44*c*. Seasonal distribution of *Stromateus maculatus*. Autumn.

movements find a close parallel in those of its near relative *Poronotus* (*Stromateus*) *triacanthus* (Peck) on the north-eastern seaboard of the United States. This 'butterfish' finds its optimum from New Jersey to Chesapeake, and its shoreward congregations in summer may be even more pronounced than those of the Patagonian species, for pound nets are the main means of capture. Near the northern limit of the butterfish, considerable quantities are trawled in Massachusetts; and in more southerly waters off North Carolina, where it was previously only known from the summer inshore fishery, small quantities have been trawled offshore in winter (Pearson, 1932, Table 2, p. 18). Thus the butterfish compares with our spotted pomfret not only in shoaling shorewards in summer, as so many useful fishes do, but also in being trawlable near the colder limits of its geographical range, and in wide dispersal to warmer and deeper waters in winter.

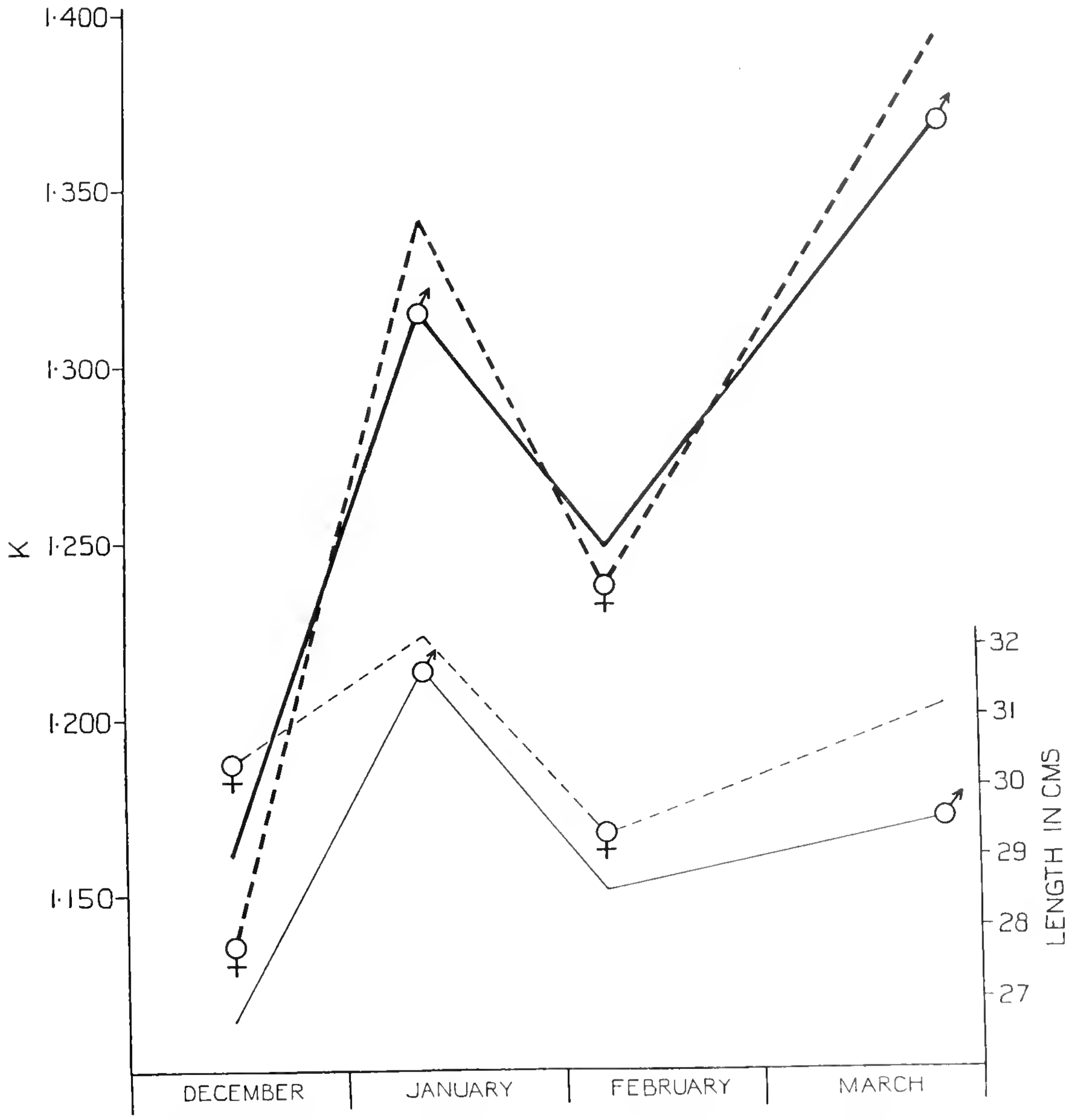

Fig. 45. *Stromateus maculatus*: seasonal variation in ponderal index, and corresponding mean lengths.

A first step in further efforts to elucidate the bionomics of *Stromateus maculatus* was to test the seasonal variation in ponderal indices for indications of the spawning season. Weight data were available only from a limited period during the third survey, and average K for either sex, plotted at mean dates, yielded the values joined by the heavy lines in Fig. 45.

This shows, first, a 27% rise in average *K* values between December and the end of March, with little discrepancy between the sexes. Secondly, an apparent drop in *K* values in February, to a level which was, however, still well above the December figures. This was found to be associated with a drop in mean lengths (thin lines in Fig. 45), i.e. with an increased proportion of smaller fish in the population sampled in February over that of the population sampled in January.

It seems fair to conclude that most spawning takes place in early summer, and further (though at this stage only as a working hypothesis) that larger fish spawn first and therefore recover condition earlier than smaller ones. The smaller fish shoal inshore later than the larger ones, as will presently be shown; and any mature individuals among them are presumably correspondingly later in spawning. But it is also quite possible that a proportion of the later, smaller shoalers are immature. If so they may still tend to decrease the mean February *K* if, like adolescent hake, they show seasonal harmonic variation in condition like mature fish, but on a lower level.

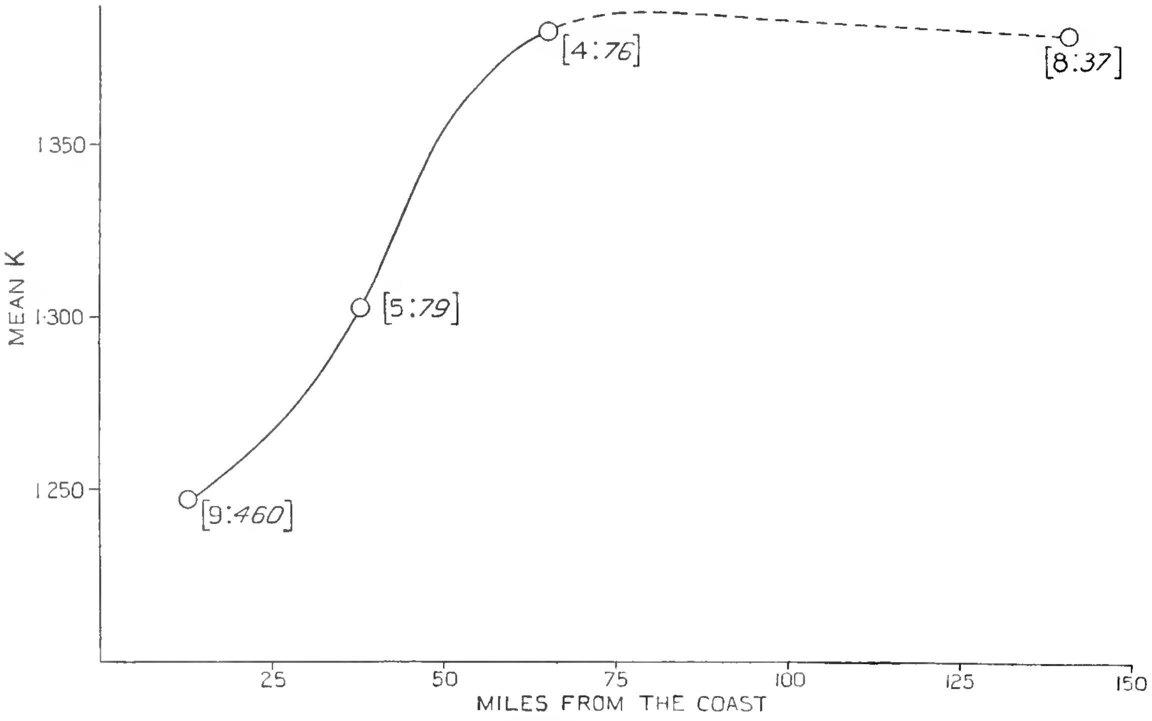

Fig. 46. *Stromateus maculatus*: variation in average *K* with distance from the coast; southern region, summer. Figures in brackets denote numbers of weighings, with the numbers of fishes measured in *italics*.

The further testing of these hypotheses as to the movements of *S. maculatus*, from the available data, depends mainly on considerations of size distribution (length frequencies) in relation to distance from the coast and at different periods; but one further application of the use of *K* seems to help, and may be described before we proceed to the other evidence. In Fig. 46 the mean *K* values of *Stromateus* taken at different distances from the coast in the southern region, in summer, are shown joined by a line (merely to guide the eye). It will be seen that the values increased sharply with increasing distance from the land. This shows that the offshore fish had had longer to recover after spawning, for it is reasonably certain that the converse explanation (inshore population spawning while that offshore had yet to do so) could not hold, for we have already seen that the general rapid increase of *K* values throughout the summer suggests that most spawning takes place early. The point becomes even clearer when the length-frequency data are considered.

In Fig. 47 the length-frequency distributions of *Stromateus* taken inshore in the southern region, in successive summer months January and February, are shown as histograms. Here we see that in January the distributions were strongly unimodal, with the mode at 31 cm. (males) or slightly higher (females). In February the distributions were clearly bimodal for both sexes, with the modes at about 25 and 30 cm. for males, 26 and 31 cm. for females, the smaller fish being more numerous than the larger. This proves the point made above, that the smaller fish moved inshore later than larger ones. It will also be shown later (Fig. 50) that in the intermediate region the length frequency of inshore *Stromateus* around midsummer resembled the February distribution in the southern region. The smaller fish in particular are thus mainly confined to the warmer inshore counter-current in their movement down the coast, but also the whole of the seasonal cycle is probably centred earlier in the

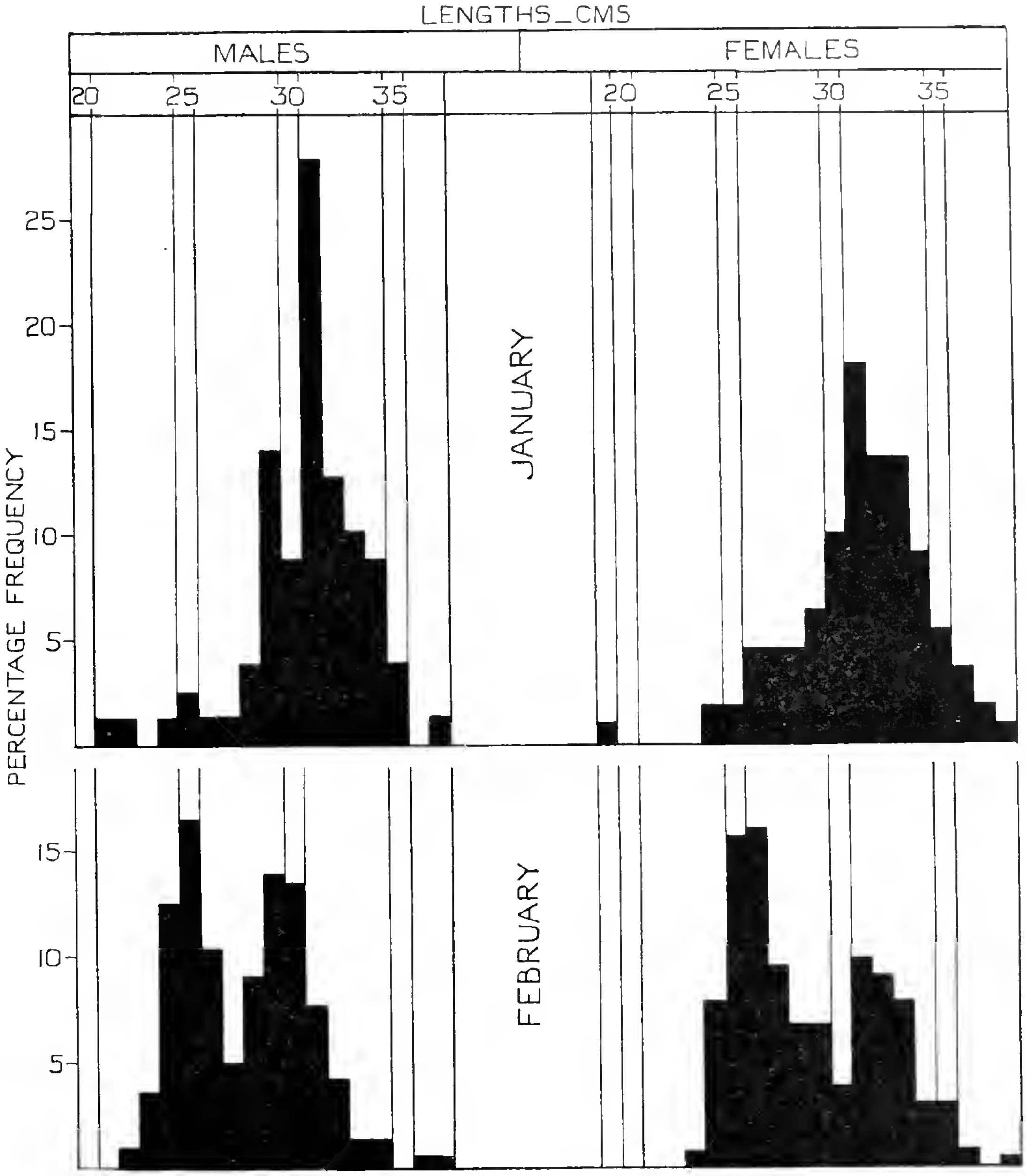

Fig. 47. *Stromateus maculatus*: seasonal variation in percentage length frequency at inshore stations in the southern region.

year farther north. Some of the northern and intermediate fish probably do not proceed so far south before they begin to move offshore again; and indeed it can be shown that the mean lengths of southern samples were significantly greater than those of fish from the intermediate region. We cannot determine the relative extent of meridional and on- and offshore trends of movement, owing mainly to dearth of inshore data from the intermediate and northern regions early in summer, particularly from the Golfo san Jorge; but it seems certain from the general distribution observed that both trends exist together.

The disposition of our catches of *S. maculatus* in the southern region in summer, the time of maximum concentration, is shown diagrammatically in Fig. 48, in relation to distance from the mainland coast. This arrangement of the data gives some idea of what a practical fisherman in quest of the species could expect, in addition to amplifying our ideas as to its general bionomics.

It is very evident that the species was most plentiful close inshore, but well distributed up to 100 miles from the land. It was rare farther offshore at this season. The sex ratio was highest inshore ('normal') and the proportion of males diminished as one proceeded seawards. The males of this species are slightly (but in large samples significantly) smaller than the females, and it is just possible that this difference has some small effect on their mobility, for we know that in other fishes where the difference in size between the sexes is more pronounced, the larger females travel farther and faster than the males. Here, however, the sexual dimorphism is so slight that one would expect that some factor not yet determined, such as more rapid dispersal after spawning among males, must be mainly responsible for the diminished sex ratios in samples of the offshore population.[1]

In Fig. 49 the percentage length frequencies of both sexes of *Stromateus* for the same area and period are considered in relation to distance from the coast, the observations being grouped according to the same distance intervals as were used in constructing Fig. 48. The inshore grouping showed bimodal distribution, with modes at about 25 and 29 cm. for males, 26 and 31 cm. for females. These probably indicate year-classes.

There was an increased tendency towards suppression of the smaller mode as one proceeded offshore, until, at distances of more than 100 miles from the land, such few fish as were caught belonged almost exclusively to the older (larger) year class.

Within a brief period around midsummer 1931–2, a series of observations were obtained that fall naturally into two groups, serving to show the strong contrast in the population of *Stromateus* inshore and that found offshore in the intermediate region, in respect of length-frequency distribution (Fig. 50). The inshore grouping showed bimodality with the smaller length-class dominant; the offshore grouping was unimodal, with almost complete suppression of the smaller class.

There are still some big gaps in our knowledge of *S. maculatus*, for pressure of work in the field upon other, more important species, made it impossible to collect routine data on the condition of the gonads, for example. We have very little idea of its diet, though some were found to have fed upon *Parathemisto*. Hake have twice been found to have preyed upon *Stromateus*, but we can only guess at its other natural enemies in this region.

The main features in the bionomics of *S. maculatus* that seem clear from our data are: a double trend of seasonal movement, inshore in spring and summer with maximum concentration, and offshore in autumn and winter with maximum dispersal; and, superimposed upon this, a meridional movement southwards in summer and northwards in winter. A schematic representation of these movements is given in Fig. 51.

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[1] Probably females have somewhat greater food requirements than males during the recovery period, with a resultant tendency towards greater local concentration where food is plentiful (though such concentrations would not be comparable with the spawning shoals). This would lead to the same result.

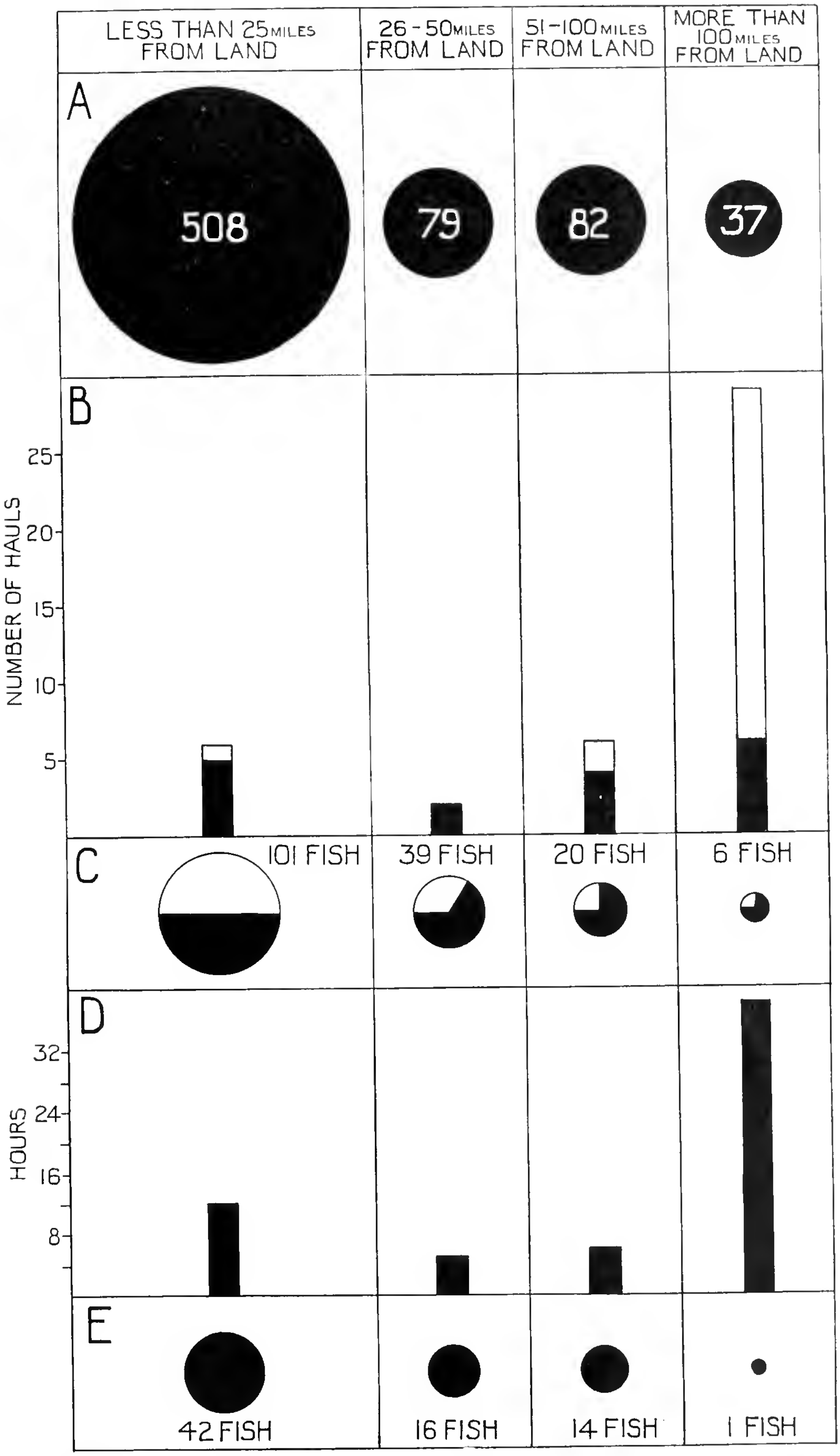

Fig. 48. *Stromateus maculatus*: relation to distance from coast in the southern region in summer. A. Total fish taken in each distance grouping. B. Number of hauls (positive black, negative white). C. Number of fish per positive haul, showing also the sex ratio. White segments indicate the percentage of males. D. Hours trawling within each distance grouping. E. Number of fish per hour's trawling.

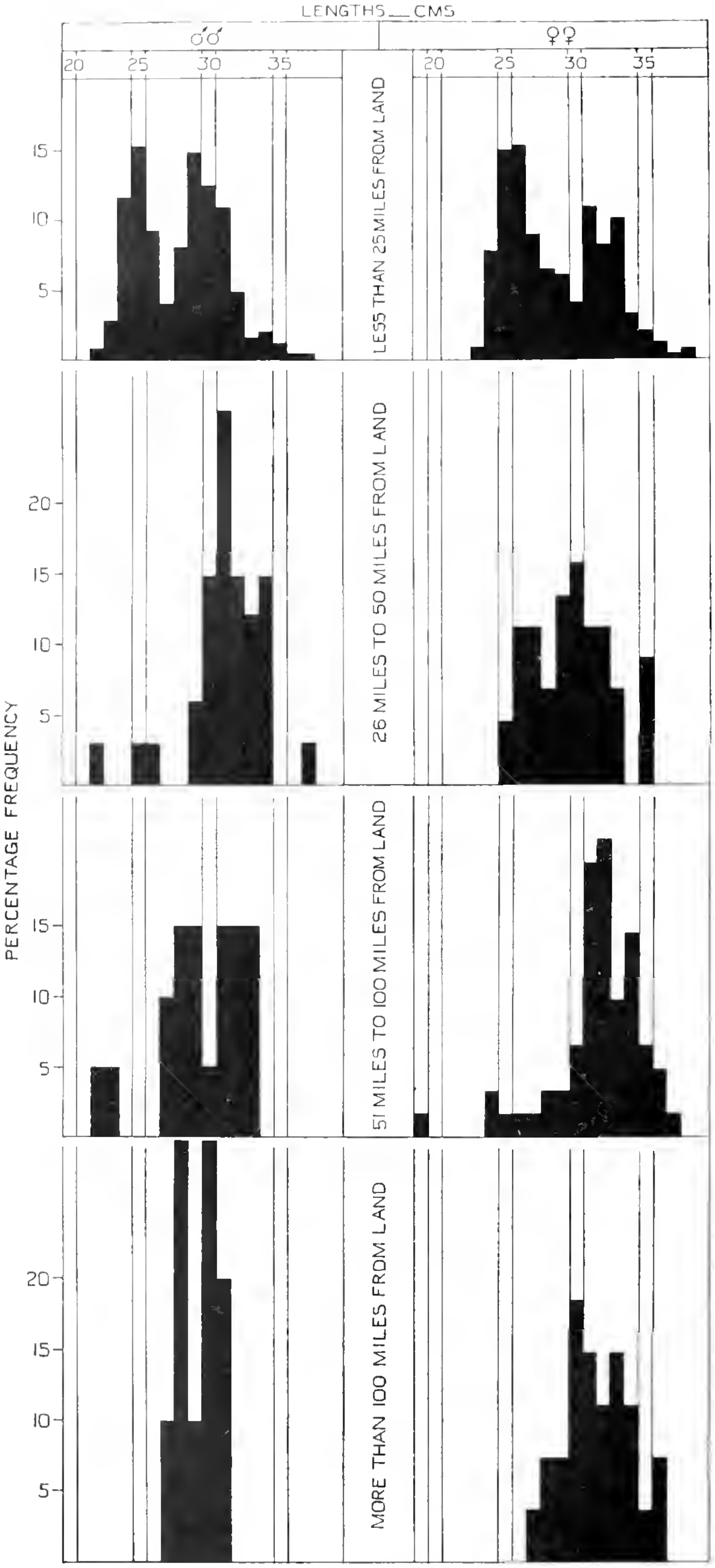

Fig. 49. *Stromateus maculatus*: percentage length frequencies at different distances from the land, southern region, summer.

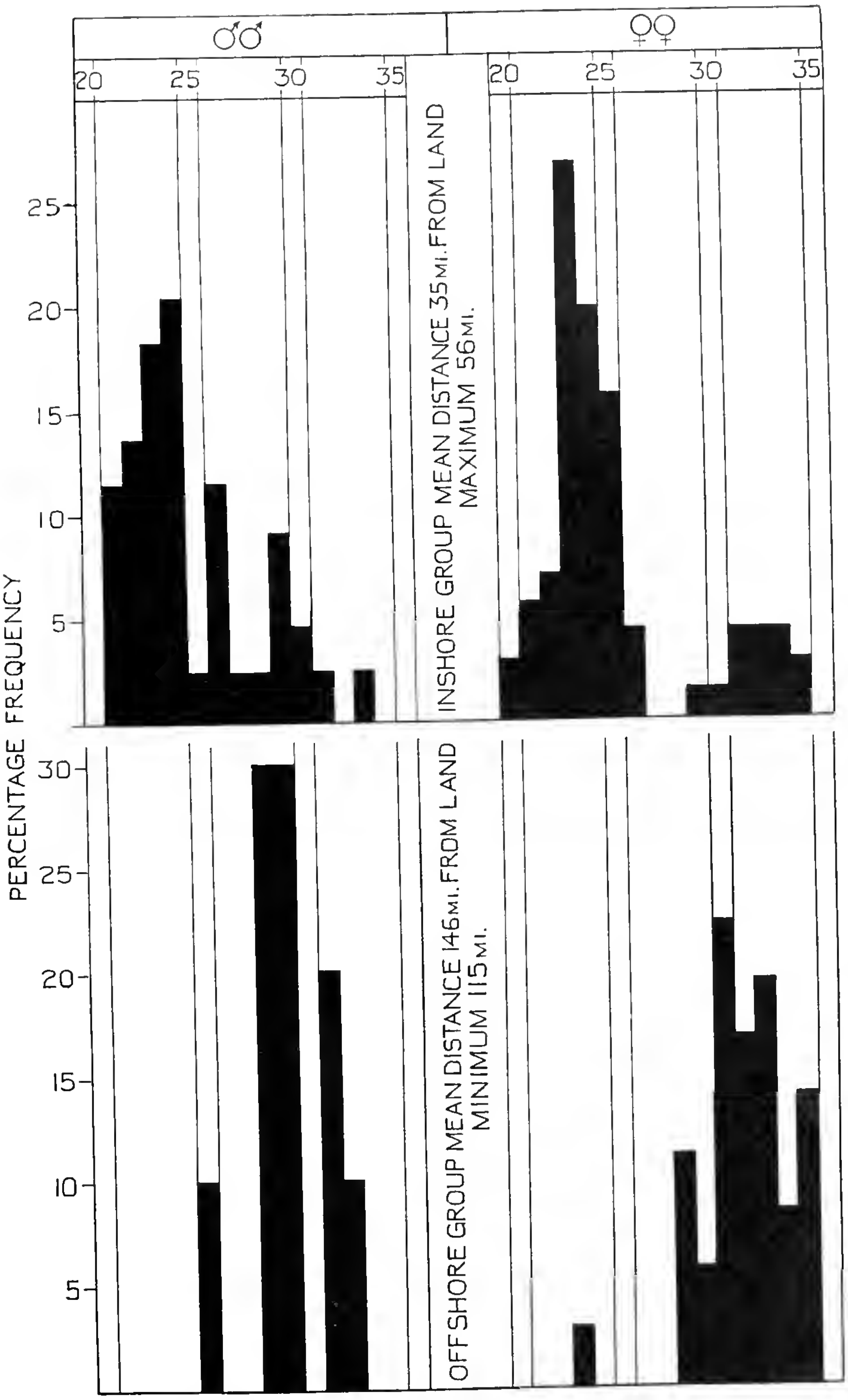

Fig. 50. *Stromateus maculatus*: variation in length frequency with distance from the coast, intermediate region, 17. xii. 31 to 9. i. 32.

Stromateus probably spawns early in summer, but we do not yet know how prolonged the spawning season may be. It seems clear, however, that the larger, older fish lead in the migratory movements, and spawn earlier than any mature individuals among the smaller ones.

The summer shoreward movement of the spotted pomfret finds a close parallel in the behaviour of the most valuable of its northern relatives, *Poronotus triacanthus* (Peck), off the southern New England, middle Atlantic and Chesapeake Bay States of America. With *Stromateus* the superimposition of a marked meridional trend of movement is probably occasioned by the necessity for maintaining a species with a prolonged pelagic post-larval phase within its ecological norm (cf. E. S. Russell, 1937, p. 321) and directly correlated with the current system of our area (Fig. 4).[1] Any similar tendency in *Poronotus* will be less obvious because of the more complex hydrological conditions of its habitat. Only the most northern parts of its range show resemblance to conditions off Patagonia. The main locus of *Poronotus* is influenced by the warm gulf-stream flowing towards higher latitudes, which is the converse of the Patagonian conditions. Moreover, the coastline in the habitat of *Poronotus* runs more east and west than the coasts frequented by *Stromateus*, and therefore any meridional component of movement will be acting more nearly in the same direction as that of the primary on- and offshore movements of *Poronotus*.

Stromateus maculatus has an extensive distribution up the west coast of South America as well as off eastern Patagonia, and Norman (1937, p. 119) has pointed out that large series of specimens from the more distant localities might reveal the existence of two or more races or subspecies. He also stated that there is some doubt as to the specific identity of the specimens reported as far north as Peru by Valenciennes. However, the narrower Peru coastal current brings relatively temperate conditions very much farther north up the west coast, than does the Falkland current off the south-east coast of South America; and since these Peruvian specimens were recorded as most abundant in the Lima market in winter, they might have resulted from seasonal meridional movement of the most northerly of the west coast stocks, in view of the known behaviour of the species elsewhere. It is well known that the extreme northward extent of the Peru coastal current leads to a more northerly distribution of other temperate types, including such fish as hake (*Merluccius gayi*), than is to be found anywhere else south of the equator.

In order fully to appreciate the potential value of the spotted pomfret in our area, it is instructive to consider the Stromateidae already exploited elsewhere. The family has been much subject to taxonomic changes, and further systematic revision—impossible without further widespread collecting—is still needed. It is hoped that Table 37 gives sufficient synonymy to leave no doubt of the identity of the species referred to. There remains the bewildering tangle of common names, many raising most interesting etymological problems, which I give with their localities in the second column. To quote individual authorities for all these would take up too much space. The object of the table is to give some idea of the range and relative importance of the Stromateidae already exploited, in compact form, before proceeding to some further consideration of their common names.

The etymology of the name 'pampano' or 'pompano' is extremely interesting. Its literal meaning in Spanish is 'a young vine branch or tendril', but the ichthyological connotation is very old, and may possibly have first applied to *Sparus salpa*. Of the ultimate origin of the word from the root 'pomum', a fruit, there can be little doubt. The Dutch word 'pampelmoes', applied to *Stromateus fiatola* in South Africa, derives from the French 'pampelmousse', the grape-fruit or shaddock (compare 'pomelo' and 'pompoleon', names occasionally applied to this fruit formerly in England). Perhaps the likeness of a deeply compressed fish seen in profile to a grape-fruit viewed in the same way accounts

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[1] Such very few *Stromateus* juv. as we captured were found *only* in the north.

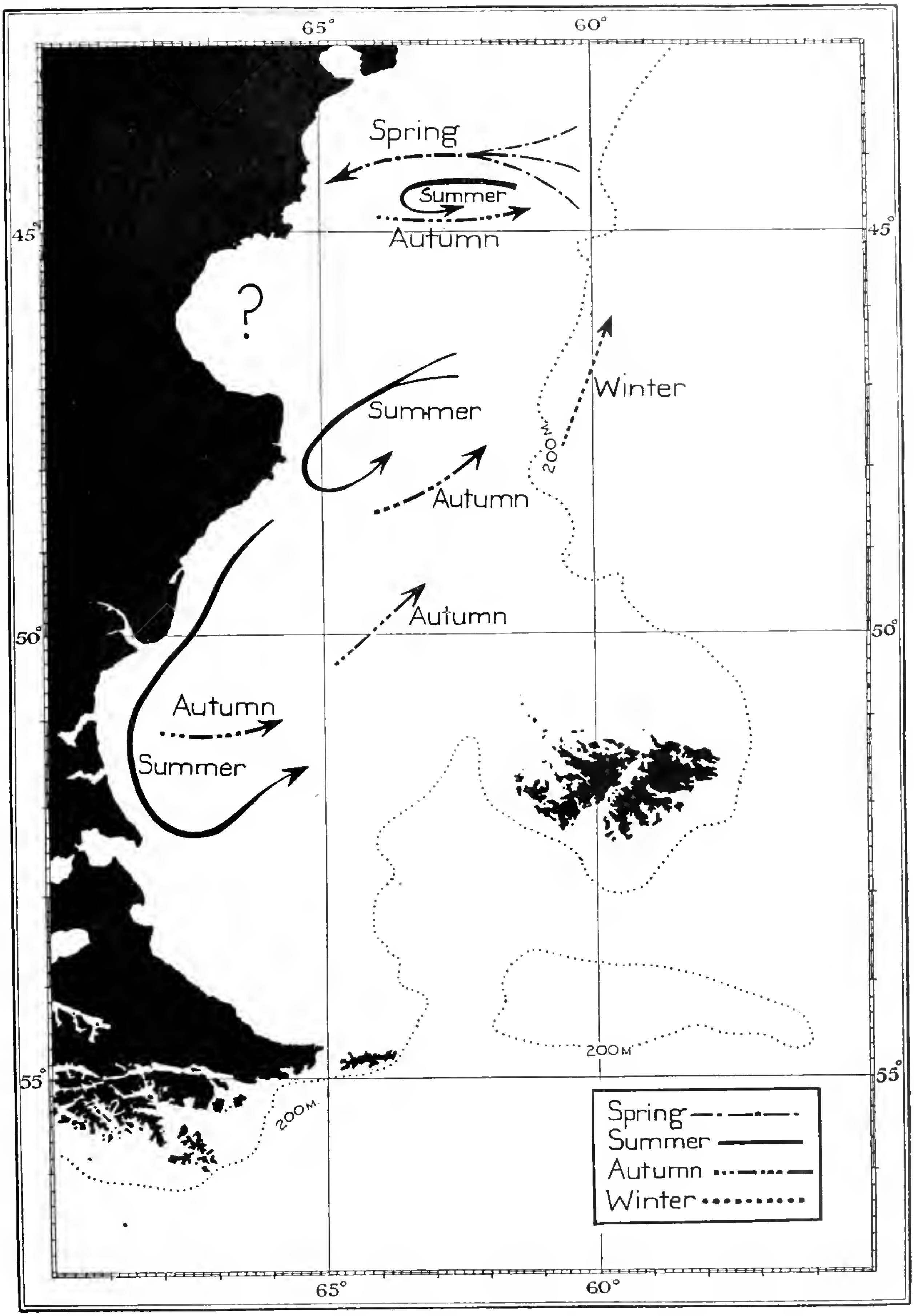

Fig. 51. Schematic representation of the probable main trends of movement of *Stromateus maculatus*.

Table 37. *Common names, range and economic importance of the principal species of Stromateidae already exploited in other regions*

Species	Common names	Range	Economic importance
Poronotus (*Stromateus*) *triacanthus* (Peck)	*Butterfish*: in Mass., and N.Y., and in modern official statistics *Dollar fish*: sometimes, in Maine *Harvest fish*: sometimes, in N.J. *Sheepshead* } sometimes, around Cape *Skipjack* } Cod *Pumpkinseed*: sometimes, in Connecticut *Starfish*: sometimes, at Norfolk, Va. *Note.* All these names are at times applied to its more southern relative *Peprilus alepidotus* (Linnaeus)	Atlantic coasts of U.S.A. from Florida to Maine, rare south of Chesapeake Bay. Biggest landings in N.Y. and N.J.	About 1 % by weight of the total fish landings of the eastern states, and 1½ % of the total value: 14–18 million lb. of fish valued at upwards of $440,000 annually. Taken principally in pound nets, otter trawls and floating traps
Pampus (*Stromateoides*) *argenteus* (Euphrasen)	*Silvery pomfret* *White butterfish* *White pomfret* } Hong Kong and Shanghai For Chinese names see Herklots and Lin (1938) and Read (1939)	Coasts of China and Japan	Important in China, and doubtless in Japan also. Formed nearly 2 % by weight of the fish, etc., marketed in Shanghai [here carp and other fresh-water species + cephalopods form nearly 20 %, so that silvery pomfret forms nearly *3*% of the *sea* fish] in 1934. Prices are above the general average at Hong-Kong and Shanghai
Peprilus (*Stromateus*, *Rhombus*?) *alepidotus* (Linnaeus). This is the same species as that called *Peprilus* (or *Rhombus*) *paru* (Linnaeus) by earlier American authors, notably Jordan, but of the two Linnean names *alepidotus* is used in recent fishery publications	*Harvest fish* in recent official statistics, but shares nearly all the vernacular names applied to the *butterfish*, with the addition of *whiting* at Norfolk, Va.	Southern Atlantic coasts of U.S.A. and in the Bahamas, etc. Rare north of Chesapeake Bay, but a few are taken in N.J. Biggest landings in North Carolina	One-tenth (or much less) the quantity of the *Poronotus* catch, but fetches as good or better prices, weight for weight, as that species. Apparently decreasing (? some possibility of overfishing) but the annual catch fluctuates violently. Taken in pound nets and seines, chiefly the former
Stromateus fiatola Linnaeus	*Pampano*: in Spain *Butterfish* *Blue fish* *Pampelmoes* *Cape Lady* } in South Africa *Adze* (romanized Arabic): in Egypt. This may have been the στρωματεύς of that Philo (? *c.* A.D. 200) who is quoted by Athenaeus (Philo ap. Ath. 7. 322*a*), but it seems more likely that he was referring to a Sparid	Mediterranean, North-West Africa, and South Africa	Esteemed as food throughout its range but nowhere taken in quantity. For example, it is too scarce to be quoted individually in South African statistics, though its good qualities are well known there
Apolectus niger (Bloch)	*Black pomfret* *Black butterfish* } in Hong Kong	From Natal to China and Japan	Of some importance in Hong Kong and doubtless elsewhere in China and Japan
Palometa (*Stromateus*, *Rhombus*) *simillima* (Ayres)	*California pompano*, *Palometa*	Pacific coast of U.S.A. from lower California northwards to Puget Sound	Highly appreciated and very highly priced, but only taken irregularly in very small quantities
Psenopsis anomala (Temminck and Schlegel)	*Small pomfret*: in Shanghai	Eastern seas	Of some value in China, one of the Shanghai species for which Read gives chemical analyses. Very little information available

for this usage. 'Pampano' is applied to *S. fiatola* in Spain to-day (Navarro *et al.* 1943, p. 132) and, as we have seen, the diminutive form 'pampanito' has been applied to our *S. maculatus* in South America, while *Palometa simillima* is sometimes called the 'California pompano'. Both words are much more widely used to describe *Trachinotus* spp., and apart from encouraging possibilities with *Stromateus maculatus*, the Stromateidae to which they have been applied are unimportant species. If there is any choice of vernacular names, therefore, I feel that 'pampano', 'pompano' or 'pampanito' should be confined to *Trachinotus* spp., clearly distinguishable from Stromateidae by the presence of pelvic fins in the adult.

'Butterfishes' has strong claims as the best alternative for Stromateidae, as the most widely accepted common name of the most important species, *Poronotus triacanthus*. Unfortunately the habitat of this species overlaps that of *Peprilus alepidotus* and, as shown in Table 37, both species share a wide range of vernacular names in the eastern U.S.A. It would be undesirable to take any step that might extend the sphere of confusion that may result from this, for as can be seen from Table 38, the name 'butterfish' is also in current use for very widely different fishes in other English-speaking countries.

Table 38. *Other usages of the chief common names applied to Stromateidae*

Chief common names applied to Stromateidae	Fishes other than Stromateidae to which these names are also applied	Localities in which such usage prevails
Pampano or pompano	*Sparus salpa* (Linnaeus)	Sometimes, in Spain
	Trachinotus spp., especially *T. carolinus* Linnaeus the common pompano	West Indies and eastern U.S.A.
	Trachinotus ovatus Linnaeus	In South Africa
	Trachinotus blochii (Lacépède)	Sometimes, in Hong Kong
Pampanito	*Trachinotus rhodopus* Gill	Gulf of California southwards to Panama
Butterfish	*Pholis gunellus* Linnaeus	In Britain
	Coriodax pullus Forster	In New Zealand
	Pseudolabrus celidotus Forster	In New Zealand, when large
	Pseudolabrus cinctus Hutton	In New Zealand, 'deep-sea' butterfish
	Johnius (*Sciaena*) *hololepidotus* (Lacépède)	In South Australia [this is the well-known Kabeljauw of South Africa]
Pomfrets	Bramidae	In Bermuda and U.S.A., notably in Jordan's writings
	Drepane punctata (Richardson)	In Hong-Kong, 'chicken-basket pomfret'
	Trachinotus blochii (Lacépède)	Sometimes in Hong Kong, 'yellow-wax pomfret'

There remains the possibility of using the name 'pomfret' for Stromateidae, with suitable prefixes. In favour of this one may urge that the usage is already widely current in eastern waters where the family attains an economic importance second only to that of *Poronotus triacanthus*.[1] *Drepane punctata*, the 'chicken-basket pomfret' of Hong Kong, need not deter us; for that is merely an attempted literal translation of a Chinese name, the fish is relatively unimportant and is already well named the 'concertina fish' in Natal. (Here we see, however, that confusion of fishes of different families under the same vernacular names takes place in Chinese as well as in the European languages.) 'Yellow-wax pomfret' for *Trachinotus blochii* is similarly an attempted literal rendition from the Chinese, and it appears that there is already a tendency to replace it by 'pompano'. (With advantage, as I think; cf. Herklots and Lin, 1938, p. 21.)

A far more serious objection lies in the use of 'pomfret' for Bramidae by a great ichthyologist like Jordan, but I cannot discover that the Bramidae (of which the type species is widely known as 'Ray's bream') are sufficiently common to be of much economic importance anywhere, so that there is not

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[1] It is even probable that the far eastern pomfrets may be relatively more important than *Poronotus*, but in considering far eastern fishes we have only limited local data to go by, in contrast to the superb U.S. statistics.

the same urgency in the matter of deciding the best common name for them. Now 'pomfret' in its ichthyological connotation is stated to be of uncertain etymology by most English dictionaries, but is I believe derived from a German word 'palmfett'—palm (oil) butter (De Vries, *German-English Dictionary for Scientists*, 1939); at least the well-known oiliness of the fishes most widely called by the name supports such a view. The use of 'pomfret' for the Stromateidae would thus preserve the literal significance of 'butterfishes', already current in America, while avoiding the confusion that may result from widespread use of 'butterfish' for other groups in other English-speaking countries, shown in Table 38. I therefore tentatively suggest 'spotted pomfret' as a suitable English common name for *Stromateus maculatus*.

ATHERINIDAE

Austromenidia smitti (Lahille). The 'William Scoresby' secured three specimens of this littoral species on hand-lines in the Golfo Nuevo, off the jetty at Puerto Madryn. Specimens from Port Stanley in the Falkland Islands, where it is not uncommon, were sent to Norman (1937, p. 120) by Mr A. G. Bennett.

Austromenidia nigricans (Richardson). No specimens of this littoral species were obtained during trawling operations, but series from East and West Falkland were sent to Norman by Mr A. G. Bennett and Dr J. E. Hamilton.

A note of E. R. Gunther's, referring to both these species, reads: '...known in the Falkland Islands as "smelt", were never taken by nets fished outside the littoral zone. They are among the most prized as food, growing to a length of twenty-two inches (56 cm.).' Norman (1937, p. 122) quotes Mr A. G. Bennett's notes on the erratic movements and shoaling habits of smelts, and their spring spawning in sheltered shallow water. From the series of measurements given by Norman it seems probable that *A. smitti* is the larger of the two species.

Already in good repute as food, Falkland smelts would appear to be among the most promising subjects for the development of any small-scale fishing industry to supply local needs.

SCORPAENIDAE

Sebastodes oculatus Cuvier and Valenciennes. We obtained more specimens of this species by casual fishing in the Magellan channels than by the systematic trawling off the east coast of Patagonia, and this suggests that the Pacific may be the real home of this fish, as it is of most other Scorpaenidae. As we have already had occasion to note, the ecological niche filled by the 'rock-fishes' in the north Pacific seems to be occupied by the characteristically southern Nototheniidae in our area.

Norman (1937, pp. 123–4) 'preferred to use the name *Sebastodes* in the wider sense of Jordan and Evermann (1898)', finding recent further subdivisions of the genus unreliable. He points out that the Patagonian species is doubtfully distinct from *Sebastodes chilensis* Steindachner, found on the west coast of South America; and is barely separable from *Sebastichthes capensis* Gmelin from South Africa, the Tristan Group and Gough Island (Steindachner himself regarded this last species as identical with the Patagonian one).

The most familiar relative of *Sebastodes oculatus* is of course *Sebastes marinus* Linnaeus, common on both sides of the north Atlantic, where it is known as the 'rose-fish', 'Norway haddock', and even (at Halifax, N.S.) as the 'John Dory'! I mention this last because I can find no record of 'John Dory'[1] referring to any fish other than Zeidae in any other part of the world, and confusion of common names is one of the greatest bugbears all fisheries workers have to face. The rose-fish has become very important commercially in recent years; it is one of the staples of the frozen fish trade in eastern U.S.A.,

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[1] Though the 'dory' part of it, if derived from the Spanish *dorado*, is a different fish altogether!

and large quantities are also taken by European trawlers off north Norway. Its Patagonian relative could be utilized, but seems to be so rare that it could never form an important part of a commercial catch.

Norman tells us that in South America *Sebastodes* is known as 'cabrilla'. This name is in much more general use for the Serranidae in warmer waters of the Caribbean Sea and elsewhere.

Specimens of *S. oculatus* were obtained by the 'William Scoresby' as shown below:

WS800B 1, length 30 cm., weight 500 g. ($K = 1·852$)
WS811H 1, length 40 cm., weight 1200 g. ($K = 1·875$) } In 'Trawl + accessory nets'
WS825 1, length 23 cm.

Fortune Bay, Baverstock Island, 5. v. 31, 2 on LH at 22 m. depth, lengths 25 and 27 cm., weights 233 and 283 g. (giving $K = 1·491$ and 1·438)

Puerto Acero, 9. v. 31, 1 on LH at 23 m. depth.

WS742A 1 in BTS at 58 m. depth.

Helicolenus lahillei Norman. We did not obtain any specimens of this species, but as Norman (1937, p. 124) gives 'coasts of Uruguay and northern Argentina' as its habitat, it is possible that it may occasionally reach the northern part of our area. A specimen of the closely allied *H. lengerichi* Norman was taken by the 'William Scoresby' during the Peru Current investigation, but this is known only from the west coast of South America.

CONGIOPODIDAE

Congiopodus peruvianus Cuvier and Valenciennes. This heavy little fish of grotesque appearance was well figured by Lt.-Col. Tenison (Norman, 1937, p. 127). It was never abundant, and is most unlikely to have any economic value, but the known facts of its distribution are of considerable biological interest.

Congiopodus has a crest-like dorsal fin supported by strong spiky fin rays. The three recurved anterior rays project over the head. This armature is supplemented by downwardly directed spines on the pelvic fins and by a most unusually tough skin. From its appearance the fish seems in no way adapted to swimming fast, but rather to hovering. The olive-coloured skin is variously spotted and marbled with dark brown or black. It matches the colour of much of the bottom deposit and may be supposed to have concealment value.

Congiopodus was found within limited areas on the plain of the shelf, mostly in the northern and intermediate regions, at different seasons and even in different years, as the records show. It was never taken at less than 63 miles from land, and only once at more than 200 miles. Further, it showed a very restricted depth distribution, all the records falling within the range 97–146 m. These data, coupled with the characteristics making for a stationary disposition already described, strongly suggest that *Congiopodus* does not wander about, but that these areas on the plain of the shelf are more or less permanent haunts. The extreme geographical range of the species is, however, wide, extending throughout the temperate waters of South America, on both coasts from Uruguay to Peru.

Our specimens of *Congiopodus*, all taken in the 'Trawl + accessory nets', were obtained at the following stations:

WS97	1	**WS792B**	4	**WS859A**	1
WS217	2	**WS793**	6	**WS859B**	1
WS790A	1	WS794	2	**WS860**	1
WS791A	1	WS800B	5	WS862	1
WS791B	2	WS807	1	WS866	1
WS792A	9	**WS855**	2		

PSYCHROLUTIDAE

Neophrynichthys marmoratus Gill. This creature of hideous aspect is locally known as 'el Gran sapo de Mar'—the great big-toad of the sea. A glance at Lt.-Col. Tenison's drawing (Norman, 1937, p. 128) shows why. It was obtained in small numbers at a few stations in the southern part of the area investigated. Although the depth range was very wide, it is perhaps noteworthy that the only haul in which it was at all plentiful was made in very shallow water just south of the entrance to Magellan Strait. The distribution appears to be correlated with prevalence of rough ground, which is perhaps a necessity for survival of such an obviously slow-swimming gelatinous creature, lacking all armament (the dermal excrescences are not spinose). Thus we found it only inshore, or out on the edge of the main slope, on ground so foul that little trawling could be done there. This distribution may be contrasted with that of *Congiopodus*, a member of the nearest related Scorpaenoid family, which, with its heavy dermal armour, inhabits the centre of the shelf:

WS93	2	*WS834*	>17	WS583	1 in BTS
WS97	1	*WS847A*	1	*WS832*	1 in NR
WS244	2	*WS851*	1	*WS877*	1 juv. in NR
WS825	1				

AGONIDAE

Agonopsis chiloensis (Jenyns). To the south *Agonopsis* was found chiefly on the shallower coastal grounds. Farther north it penetrated to the centre of the shelf also, and there some 30% of our specimens were secured. Its distribution is of great interest, for it seems to show a strong tendency to remain in localized areas, roughly intermediate between the contrasted types of distribution shown by the two species last mentioned, and in conformity with what one might infer of its habits.

The fish is small, seldom exceeding a length of 15 cm., and the body is, in Boulenger's words, 'completely cuirassed with osseous scutes', giving it a lizard-like appearance. The body is marked by a number of brown cross-bars on a sandy buff background. Beyond a very evident lack of agility there is little direct evidence as to its habits.

The colour of *Agonopsis* was often matched by hauls of buff-coloured invertebrates such as the hydrocaulus of tubularians and the reef-like polyzoan *Smittina* among which it was found; or the sand, shell and coral fragments of the bottom deposit.

Agonopsis was often caught in the Russell bottom-net. Unless these were individuals behaving in an exceptional manner, it shows that the fish rise when disturbed, or alternatively are in the habit of swimming several inches above the sea-floor. The small flatfish *Thysanopsetta* lives right on the bottom and was very commonly caught in the fine nets attached to the back of the trawl, but was taken in the Russell net only once.

As can be seen from Fig. 52, *Agonopsis* was caught in five separate localities. The conclusion that this indicates a stationary habit is borne out by the fact that within each group catches were secured in different months. In the most northern of these localities the fish were met with in October, December and March; in the most eastern (Falklands area) in February, May and September; while in two others the fish were met with in different years:

WS71	20	*WS243*	1	*WS583*	5 (in BTS)
WS81	2	WS787	4	*WS754*	3 (in NR)
WS83	4	**WS791B**	1	**WS767**	1 (in NR)
WS93	1	WS799A	1	*WS832*	3 (in N100B)
WS95	5	WS800B	1		6 (in NR)
WS216	1	*WS847A*	1	*WS836*	2 (in BTS)
WS219	1	**WS860**	1	**WS852**	1 (in BTS)
WS221	1			*WS873*	Post-larvae present (in NR)

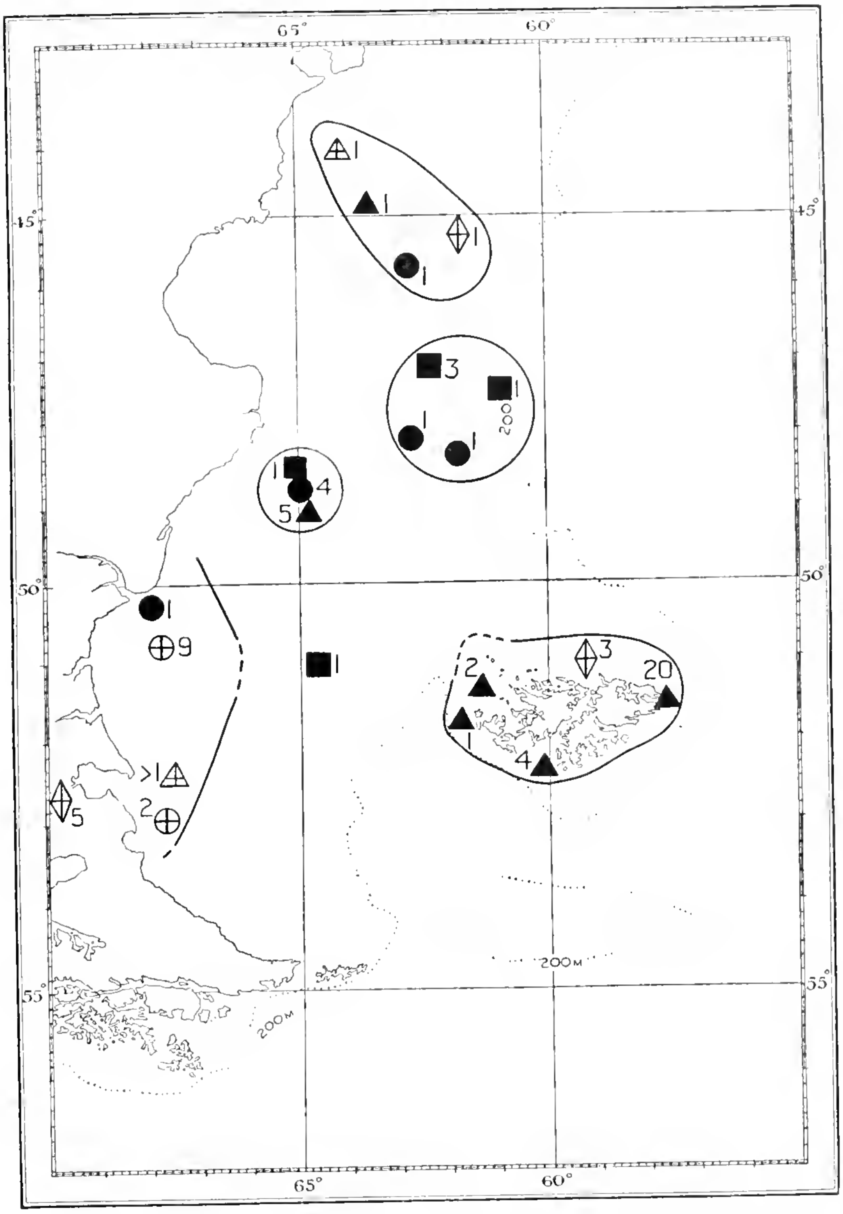

Fig. 52. Distribution of *Agonopsis chiloensis*: positive records only, roughly contoured to show their localization in different seasons. Diamonds, spring; circles, summer; triangles, autumn; squares, winter. Solid symbols represent captures in 'Trawl + accessory nets'; cross symbols with 'Other gear'.

LIPARIDAE

Careproctus falklandica (Lönnberg). Six specimens of this fish were trawled at St. WS89 off Cape Virgins, in April 1927. It was previously known only from the Falkland Islands and the Burdwood Bank. This suggests a distribution similar to that of *Neophrynichthys*, which it resembles in having a soft and gelatinous body. Its colour in life was pale orange.

Unidentified liparids were obtained at two stations in the Magellan Strait, outside the area of the trawling surveys.

BOTHIDAE

Thysanopsetta naresi Günther. This small flatfish, resembling the 'scald-fish', *Arnoglossus laterna* (Walbaum), of British seas, was the only member of the family at all numerous in catches obtained during the trawling surveys. Its small size renders it unsuitable for human consumption, the largest

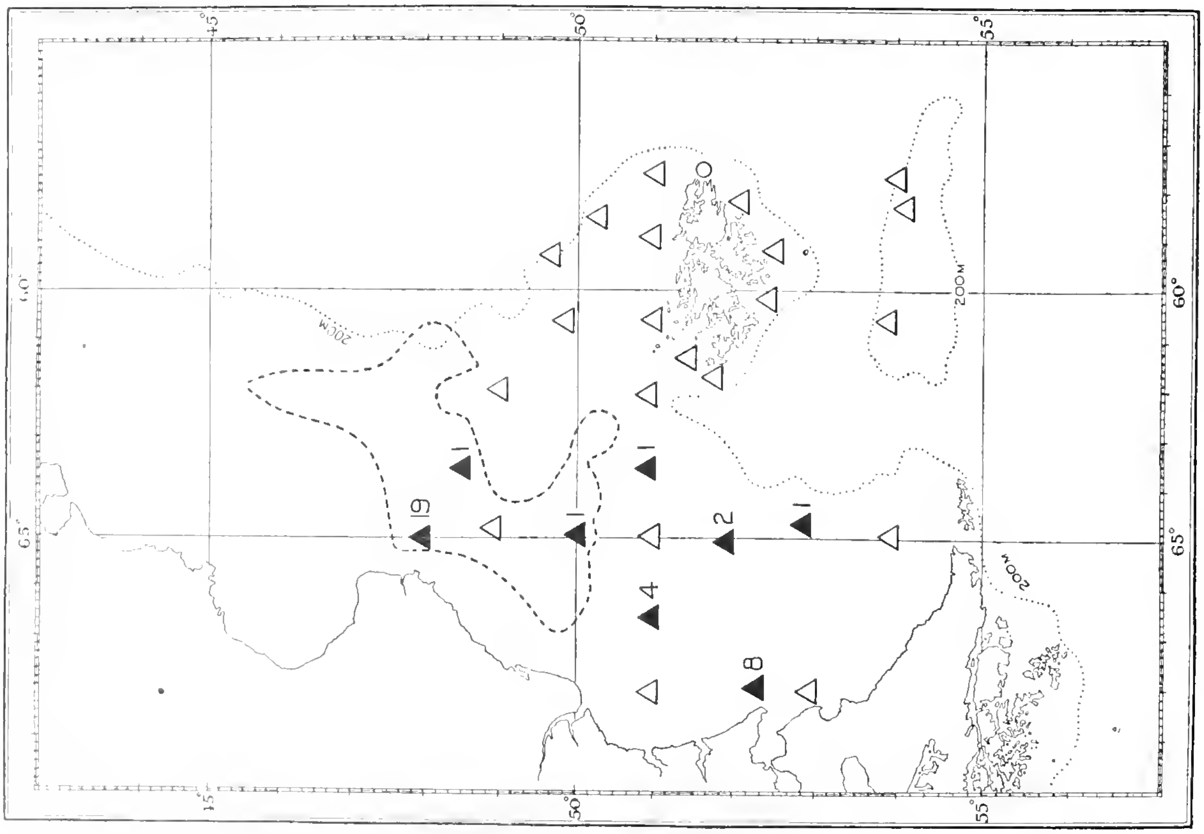

Fig. 53*a*.

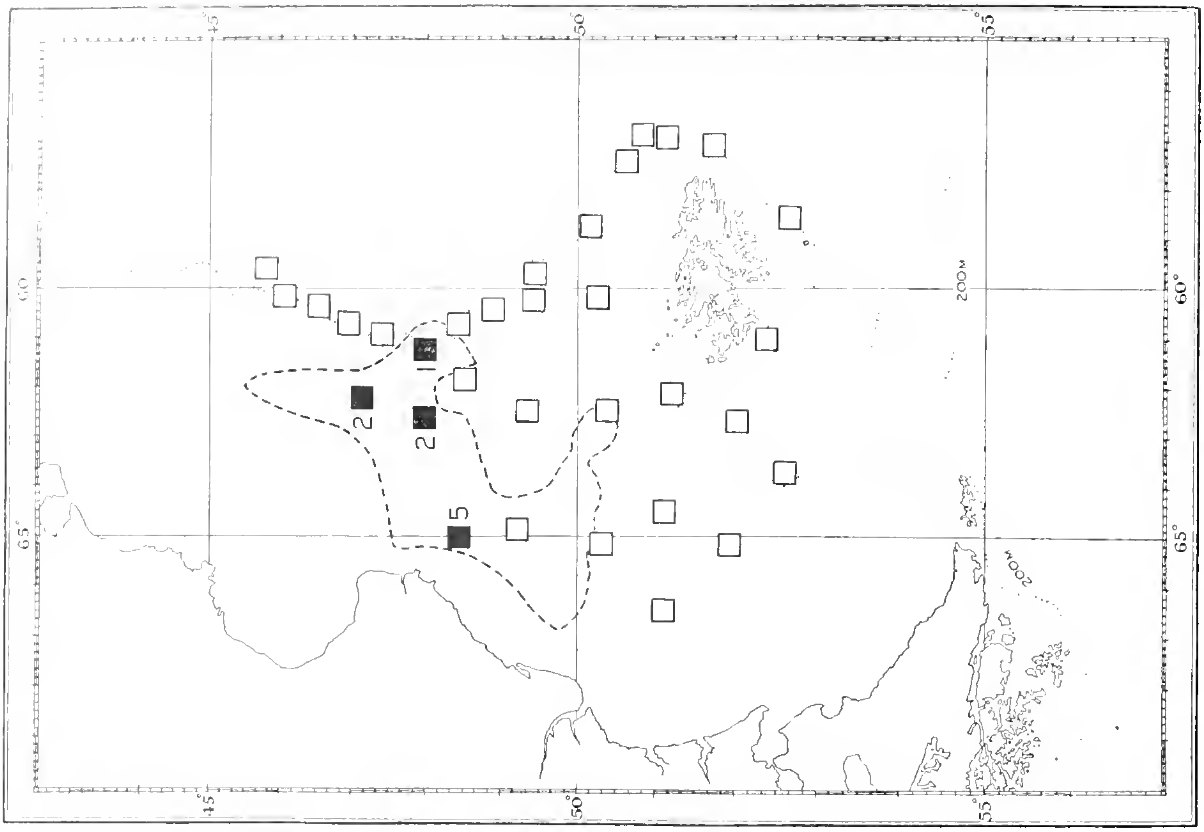

Fig. 53*b*.

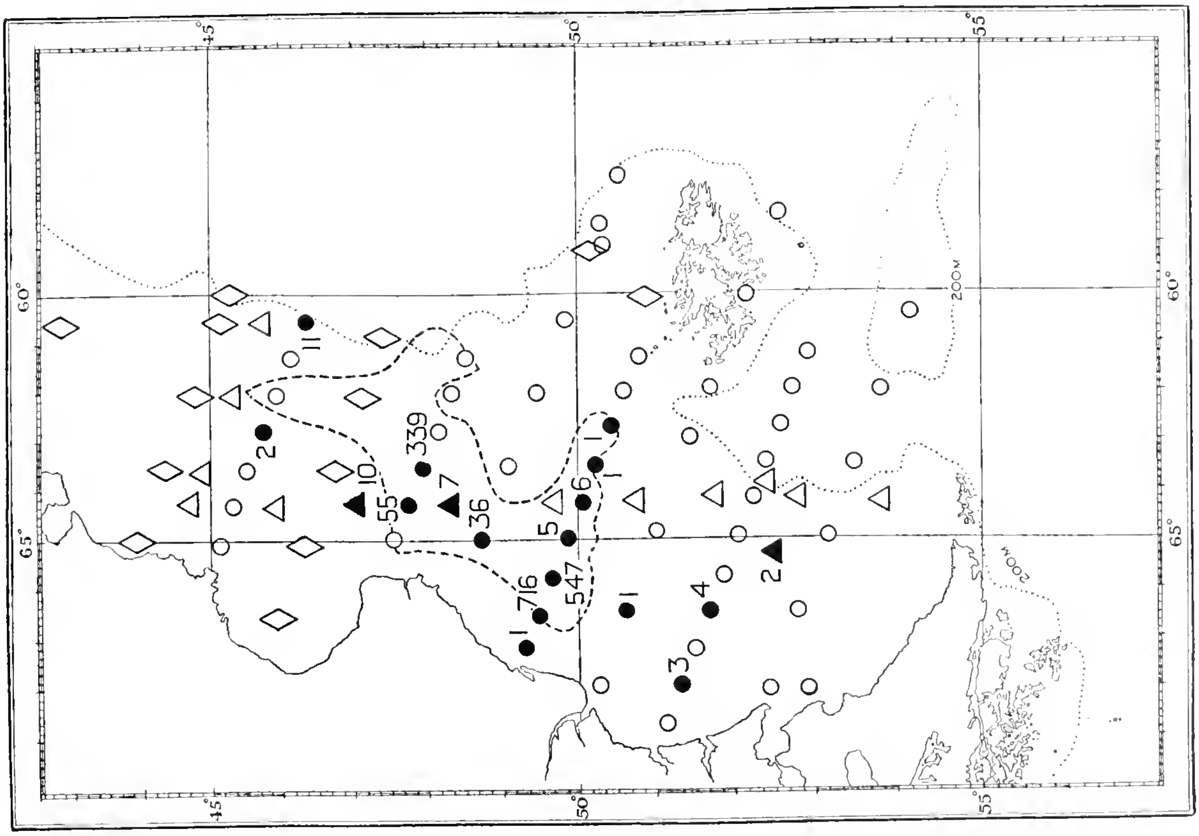

Fig. 53c.

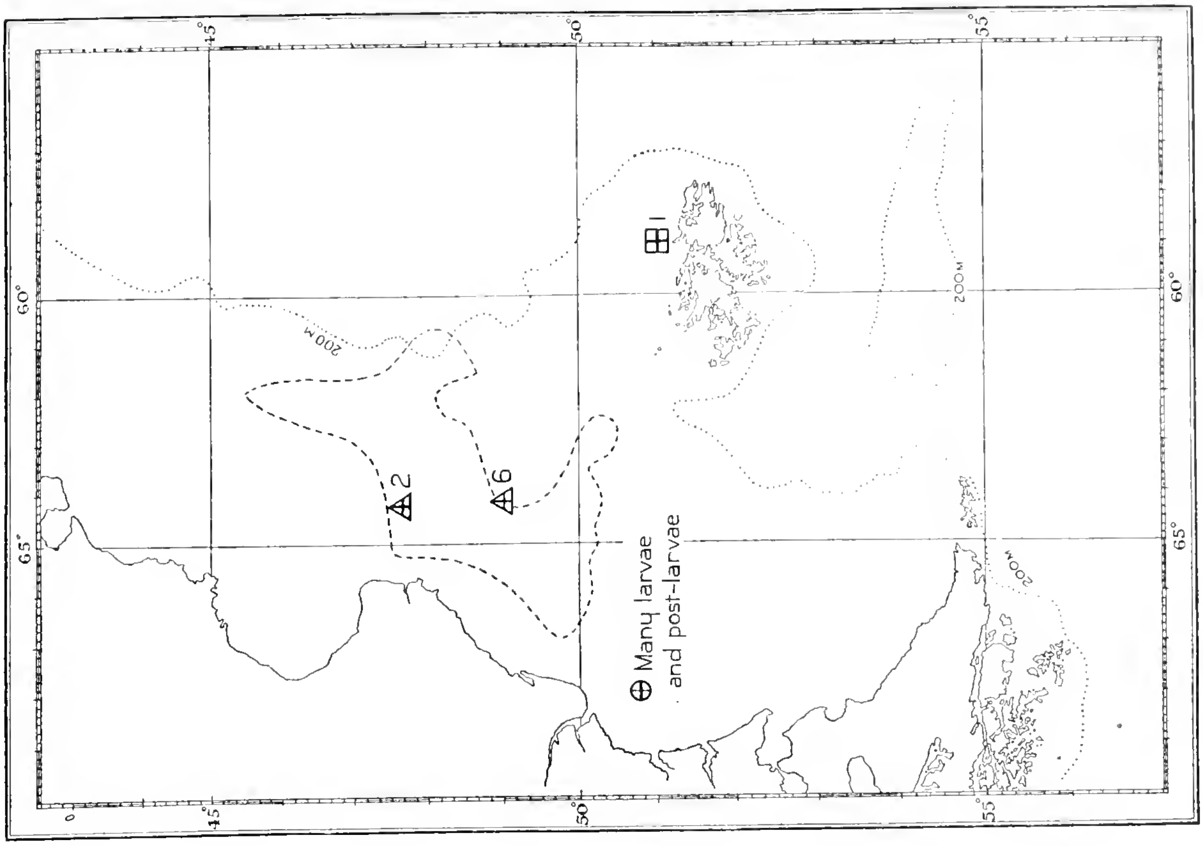

Fig. 53d.

Fig. 53. Seasonal distribution of *Thysanopsetta naresi* showing also its relation to the central area of brown sand delineated by Matthews. *a*, first survey; *b*, second survey; *c*, third survey, all showing records from 'Trawl + accessory nets', with negatives; *d*, captures with 'Other gear', positive records only. Diamonds, spring; circles, summer; triangles, autumn; squares, winter.

captured being only 14½ cm. long. As forage for larger species, of greater potential economic value, *Thysanopsetta* is evidently of considerable local importance, for, as we have already seen, it figured largely in the stomach contents of hake (*Merluccius hubbsi*) and *Thyrsites atun*, as well as in more typical bottom-feeders such as *Cottoperca gobio* and some of the rays.

The distribution of *Thysanopsetta* is very interesting. It seems to be peculiar among the fish fauna of the shelf in being influenced more by the nature of the bottom deposit than by any other distributional factor.

Some seasonal movement there is, for when the catches are charted (Fig. 53) it can be seen that the fish were farthest south in autumn, farthest north in winter, and nearest to the mainland coast in summer. These trends agree in time and direction with those followed by most other fish in the region that show seasonal movements, but were much smaller in extent, so that *Thysanopsetta* was rarely found far from its 'metropolis' on the central area of brown sand that occupies most of the plain of the shelf in the intermediate region. This was delineated by Matthews (1934, pl. xiii), when he was working on the bottom deposits obtained with the dredge during the trawling surveys, long before the fish data had been worked up. The close correlation between this deposit and the distribution of *Thysanopsetta* was first seen by E. R. Gunther, and was very clearly described by him in a preliminary (verbal) account of these surveys. He had subsequently altered the manuscript so drastically that I have had to attempt an independent presentation of the data (Table 39) and can only hope that this will prove adequate, in conjunction with the charts.

Table 39. *The relation between a localized type of bottom deposit and catches of the flatfish* Thysanopsetta naresi

Figures in **heavy type** relate to observations made **within the central area of brown sand**, delineated by Matthews (1934, pl. xiii); figures in *italics* to observations made *elsewhere, on other deposits.*

	First survey		Second survey		Third survey	
No. of hauls	**4**	*25*	**7**	*27*	**19**	*85*
No. of hauls positive	**3**	*5*	**4**	*0*	**12**	*9*
% occurrence	**75**	*20*	**57**	*0*	**63**	*10·5*
No. of fish caught	**21**	*16*	**10**	*0*	**1712+**	*35*
Hours' trawling	**4**	*24*	**7**	*27*	**34**	*109¼*
Hours' positive hauls	**3**	*5*	**4**	*0*	**21**	*15*
Rate of capture: Per hour's trawling	**5·2**	*0·7*	**1·4**	*0*	**50·0**	*0·3*
Per hour's positive hauls	**7·0**	*3·2*	**2·5**	*0*	**81·0**	*2·3*

It also seems clear that *Thysanopsetta* is most concentrated (i.e. most given to shoaling) in summer. Its absence from our few spring hauls should not be considered as evidence of the converse (greatest dispersal at that season) for they were nearly all worked to the north of the normal limits of distribution of the species. It is more likely that *Thysanopsetta* is most widely dispersed during winter.

Thysanopsetta naresi is evidently a true bottom-dweller, and even more so than some other species of flatfish inhabiting similar depths, for the latter often show by the nature of their food that they must spend a considerable part of their time swimming clear of the bottom. We know that *Thysanopsetta* must lie exceptionally close, because although it was so frequently captured in the accessory nets attached to the back of the trawl, it was only once taken in the Russell bottom net. This is designed to fish a few inches clear of the bottom, and very many hauls were made with it in regions where *Thysanopsetta* was known to be plentiful. It is the more remarkable that such (normally) semi-pelagic feeders as hake and *Thyrsites* were found to have fed extensively upon *Thysanopsetta*. I believe that the explanation partly lies in the uniformly moderate depths over the plain of the shelf, for this brings the bottom fauna well within reach of larger predators which are given to diurnal vertical migration, and which have to be satisfied with a mainly pelagic diet when in deeper waters. Further, the hake are to be found in the *Thysanopsetta* area just after they have spawned, and at that time, as is well known, they eat everything within reach.

The greatest concentrations of *Thysanopsetta* were found near the southern and inshore limits of its main habitat, in late summer. Its concentration there may be correlated with the relatively warm and intermittently southward flowing inshore surface water. One would suppose it to be a prime requisite for survival that the post larvae should attain the bottom-living stage before being swept north of their ecological norm in the main path of the Falkland current. On these premises it seems a fair hypothesis that spawning will be found to take place near the southern limits of the species' range. It is also possible that the period of the pelagic phase may be shorter than is usual in allied species, thus making for quick settlement upon suitable terrain, but the only factual support for this suggestion comes from a single rich haul of post-larvae secured with the Russell bottom-net, slightly to the south of the main *locus* of the species, in the late summer of 1930–1 (St. WS832). Here also larvae were taken in plankton nets fished nearer to the surface. Adults have never been taken (in numbers) much farther south than this, so it seems certain that these larvae must have resulted from a very recent spawning:

WS77	4	WS795	11	*WS814*	4
WS80	1	WS796A	333	*WS848*	1
WS90	8	WS796B	6	WS857	10
WS91	1	WS797B	43	WS862	7
WS92	2	WS797C	12	*WS874*	2
WS94	1	*WS804A*	1		
WS96	19	*WS805*	1	WS742B	1 (in BTS, Mocha Island, west coast)
WS97	1	*WS806*	6	*WS832*	20 larvae (in plankton nets)
WS216	1	WS807	5		95 post-larvae (in NR)
WS219	3	WS808	547	WS861	2 (in BTS)
WS220	2	WS809A	713	WS863	6 (in BTS)
WS222	5	WS809B	34	*51*	1 (in OTL)
WS787	36	WS810	1		
WS791B	2	WS811II	3		

Hippoglossina mystacium Ginsburg. Norman (1937, p. 132) records this species (which is closely related to the more northerly *H. macrops* Steindachner, of the west coast) from Magellan Strait, so it may occasionally penetrate to the eastward, although we did not find any.

Paralichthys patagonicus Jordan and Goss. This is an east coast species, but its main habitat lies far to the north of the area of the surveys, and we did not capture any. Several specimens of *P. microps* (Günther) were obtained by the 'William Scoresby' off the west coast, but this species is not known to extend 'round the corner'. According to Norman it is sometimes called 'lenguado' in South America, but this common name for flatfish (used for *Solea* in Spain) is applied so promiscuously that it is safer to regard it as a family name to be applied to any small Heterosomata (just as the ancient word 'butt' is still used in parts of East Anglia, usually for flounders, but without any intention of specific distinction).

Paralichthys isosceles Jordan. This is one of two flatfish of the area surveyed that are big enough to eat; it is sometimes over a foot in length and half a pound in weight. We found very small numbers not infrequently in shallow water (90 m. and under) in the extreme north. None was taken south of lat. 46° S:

WS762	1	**WS788B**	1
WS762B	1	**WS853**	2
WS763	3	**WS852**	1 (in BTS)

Xystreurys rasile (Jordan). We found this species also in the extreme north of the area surveyed, but it was very rare. Norman tells us (1937, p. 135) that it, too, is called 'lenguado', which suggests that somewhere—perhaps farther inshore, or altogether to the north of our area—it is more common. *Xystreurys* also reaches 'pan-size'.

Mancopsetta maculata (Günther). A single specimen of this rare species was obtained during the trawling surveys at St. **WS218**, in deep water over the edge of the shelf, just north of the southern boundary of our northern region. It was 24 cm. long. Norman (1937, p. 136) refers to this specimen as taken 'north of the Falkland Islands'. This is true, of course, but might well obscure the fact that it was well over three hundred miles to the north of them. This capture off the Patagonian shelf is interesting because the species was previously known only from the holotype collected by H.M.S. 'Challenger' in 310 fm. (567 m.) off Prince Edward Island in the Indian Ocean. Although such wide distribution is not unknown among more versatile pelagic fishes, such as *Thyrsites*, this is the only example known to me in a group so specialized as the Heterosomata. E. R. Gunther noted 'it is evidently a species inhabiting deep water and is unlikely to be of commercial value'.

Achiropsetta tricholepis Norman. This genus was discovered during the investigations here described. Two specimens are known. One, 10 cm. long, was taken at St. WS89 off Tierra del Fuego. It was noted as 'having a grey colour, but highly transparent so that heavy print could be read through most parts of the body'. In 1932 further hauls were made round the position of St. WS89 in hopes of finding more, but none was taken.

The other specimen had been found at the Falkland Islands some years previously, but was not reported until the publication of Norman's paper in 1937 (p. 136). It was seen from the jetty in Stanley Harbour swimming near the surface, and was caught in a bucket by Mr Bert Radclif. Dr J. E. Hamilton into whose hands the specimen passed had independently noted the transparency of the living fish. E. R. Gunther suggested that the transparency may be related to a surface swimming habit, accounting for the virtual absence of the fish from our bottom nets, and its occurrence on both sides of the Falkland trough:

WS89	1, of 10 cm. in the trawl
Port Stanley ?1922	1, of 10·5 cm. (J. E. H.) in a bucket at the surface

FEATURES OF GENERAL BIOLOGICAL INTEREST

To draw up a useful formal summary of a work of this kind would be difficult, and perhaps even impracticable. It is a long report, but it is in itself little more than a collection of summaries, for it deals only with the more important aspects of a body of data too vast to be analysed in full at present; and for some species the text is already compressed to only a few lines. The present section, however, may serve a useful purpose in focusing attention on some of the features of general biological interest that have emerged. These have already been discussed as fully as the data allow, in the notes on the several species. First, however, I take the opportunity to repeat, in as near to summarized form as possible, the essential features of the environment described in the introductory sections. These must constantly be borne in mind if the other features are to be properly appreciated.

The Patagonian Continental Shelf is the largest expanse of sea shallow enough to support a considerable population of demersal fishes, in the cold temperate zone of the southern hemisphere. That part of it which we surveyed, between 42 and 52° S lat., is rather larger than the North Sea. The main **physical features** of this area are:

(1) Uniformly moderate depths over the 'plain of the shelf' with very slight depth gradient as one proceeds offshore from the 80 m. to the 200 m. contour. Abrupt descent to oceanic depths 'over the edge'. (This means that there is but a very small area below 200 m. accessible for trawling, despite the great width of the shelf.)

(2) Rough ground with coralline hydroids and coarse deposits prevails to the south, and in many places along the shelf edge. Finer deposits are found to the northward, with better conditions for trawling.

(3) The main current affecting the area is the relatively cold Falkland current flowing from south to north, coldest along its offshore margin. The warm Brazil current impinges upon this offshore in the extreme north-east of the area, where the hydrological conditions may be very complex, but this is too far offshore normally to affect conditions on the shelf. On the inshore flank of the Falkland current (which is a movement of sub-Antarctic surface water) the flow is not so strong, so that 'old shelf water' is warmed and sometimes even flows southwards as a small intermittent counter-current close in to the land. This seems to have an important effect on the distribution and movements of some of the fishes.

(4) The annual cycle of surface temperatures is centred lower than in corresponding latitudes in the northern hemisphere, with the peak after mid-summer; and the annual range is small. At greater depths, while the range of temperature is of course even smaller, the time lag between sea and air temperatures is even greater, so that bottom temperatures are highest in autumn and lowest in spring or early summer.

Some preliminary observations on plankton conditions have been discussed, but the large collections obtained will require many years working up by specialists before one could fully consider the interactions of this part of the biological environment with the fish fauna. The same must be said of the copious collections of benthos. However, with regard to the plankton conditions, at least, some important features are already fairly clear. While the general facies of the plankton is closely similar to that found in cold temperate waters in other parts of the world, two major differences are already discernible.

First, with regard to the **phytoplankton conditions** (the basic element in the life cycles of any sea area) it seems reasonably certain that the onset of the main increase falls later in the year than in corresponding latitudes in the northern hemisphere, especially along the outer edge of the shelf. Production probably begins earliest inshore, owing to more favourable conditions for the establishment of a thermocline, but even so the cycle is later than (say) on the hake grounds south of Ireland. Dependent cycles of higher organisms must therefore also be centred later in the year, the whole 'plankton-calendar' (Bogorov, 1941) being later. Even the larger nekton (fish and squids), all of which must be affected directly or indirectly by the plankton conditions, must be expected to show a similar 'lateness' in their biological seasons. Direct evidence of this is already forthcoming in a few instances, as in the apparent spawning times of some of the fishes. Species apparently corresponding to spring-spawners elsewhere here seem to spawn around mid-summer, and whereas hake may generally be regarded as summer spawners the local species has been found ripe chiefly in early autumn, although some had certainly spawned earlier.

Secondly, with regard to the **zooplankton**, although euphausians, *Parathemisto*, and calanoid copepods are prominent among the larger Crustacea, as elsewhere, there is a notable local abundance of 'lobster-krill', the pelagic post-larvae of two species of *Munida*. This is paralleled elsewhere only in New Zealand waters (where one of the same species occurs) and on some parts of the Pacific coast of North and South America. Off Patagonia lobster-krill are an important food of whales and seals, birds and fishes, especially the younger individuals of the larger fishes, that later become almost exclusively ichthyophagous, like the hake. (This is equally true of *Munida* in New Zealand waters, where they are commonly referred to as 'whale-feed'. See Matthews (1932), and Rayner (1935).)

Proceeding to general consideration of the **fish fauna**, as a whole: its chief characteristics have been illustrated by comparison and contrast with the faunas of better known fishing-grounds elsewhere.

Clupeoids are important, but our methods, aimed at investigating the ground-fish, could not demonstrate their relative quantity, even roughly. It is very clear however that they are a staple food of the larger mid-water and ground-fish, and, indeed, of all larger creatures in the region capable of swallowing them.

Systematically, the two most prominent groups of ground-fishes were the Nototheniiformes and Zoarcidae. The Nototheniiformes are a large group whose metropolis is the Antarctic Zone, but the Patagonian species, although concentrated mainly on the southern part of the shelf, show only two examples common to both regions. This suggests that dispersal between the Antarctic and sub-Antarctic Zones has for long been difficult, and the hydrological barrier presented by the Antarctic convergence may be the prime factor involved. The Zoarcidae (eel-pouts) prominent elsewhere in the North Pacific and in the Antarctic Zone, provide a large number of species, but were taken in such small numbers that they are thought to be of little ecological importance.

Two Merlucciidae, a true hake and the 'long-tailed hake' (*Macruronus*), were dominant among the larger fishes, and were surpassed in numbers only by the most widespread of the Notothenias (*N. ramsayi*), a much smaller species of little potential value to man. Gadidae and Heterosomata were few and small. Elasmobranchs also were less important than on most other roughly comparable grounds, dogfish being particularly scarce. The Rajidae provided a profusion of local species difficult to determine, but their numbers were few and sizes small. In general the fish fauna resembled that found in the North Pacific more closely than that of other known fishing grounds, if we regard the Nototheniiformes as filling an ecological niche similar to that occupied by the smaller 'rock-fishes' of the North Pacific. Jordan (1905, II, p. 501) had pointed to this last similarity. There are two outstanding and discouraging differences between the two areas: the North Pacific abounds in salmon and sizeable Heterosomata, but on the Patagonian shelf, salmon are absent and the only common flatfish too small to be of use. However, the absence of salmon is a drawback shared by the whole of the southern hemisphere, except where small-scale artificial introductions have been made.

Apart from the hakes, another Patagonian fish is to be found in some plenty in summer, and might eventually be exploited with profit. This is the 'spotted pomfret' (*Stromateus maculatus*). Near relatives of this species, whose commercial value has already been proved, are the butterfish of north-eastern U.S.A. and the silvery pomfret of China seas.

The fish fauna of the Patagonian Continental Shelf is notably poorer in species than that of roughly comparable areas elsewhere: nearly twice as many species are recorded from the Gulf of Maine, and more than three times as many from British seas. Unfortunately, it would seem that there is a corresponding lack of quantity of fish that can be trawled, apart from the three most promising species.

The study of distribution, migrations and general biology of demersal fishes has proceeded apace wherever commercial fisheries are pursued. A vast body of evidence concerning these subjects has accrued, but, with notable exceptions (such as Meek, 1916; and Kyle, 1926), little attempt at synthesis has been made. Certain broad similarities of behaviour, especially in respect of migration, are common to many demersal fishes of the most diverse philogenetic origin. One can hardly call these tendencies 'rules', for there are too many obvious exceptions, but they are followed more or less closely by a majority of the species inhabiting extra-tropical waters, and thus provide an invaluable aid to the ordering of our thoughts on the bionomics of the several members of a fish fauna. Fisheries workers will be very familiar with the tendencies I have in mind, and many more beside, but it is desirable to state a few of them here, because they form a convenient guide to the general biological usefulness of the data presented in the main body of this report, that is to say the notes on the individual species. The main value of such work, from the general biological point of view lies, not so much in discoveries of odd individual deviations from 'normal' behaviour, as in seeing how far most members of a fauna not previously studied or exploited, conform to tendencies recognizable elsewhere. (By this means lesser divergencies, such as time-lag, usually become clearly attributable to the differing environmental conditions). To proceed:

Many demersal fishes show seasonal movement shorewards in summer, and offshore to deeper water in winter. Usually, but not always, the shoreward movement is a breeding migration.

This is one of the best known tendencies of fish migration. Examples among Patagonian species are furnished by fishes as diverse as hake (*Merluccius hubbsi*), spotted pomfret (*Stromateus maculatus*), a ray (*Raja brachyurops*) and *Notothenia ramsayi.*

In a migratory species of ground-fish, the larger individuals tend to travel farther and faster than the smaller ones. (Often the movement of immature individuals is so limited that they never proceed 'over the edge' to the greater depths reached by the adults during the 'off' season).

Very good examples of this are provided by the four species mentioned above.

A similar effect may be apparent interspecifically among the members of a taxonomic unit. Thus hake migrate more extensively than the slighter *Macruronus*; and *Notothenia ramsayi*, the largest of the Patagonian members of its genus, migrates farther than any of the others.

In temperate latitudes many migrating species of demersal fishes extend their range polewards in summer and towards the equator in winter. This may result directly from the effect of temperature, but is not (as yet) clearly to be distinguished from secondary effects of the strength and direction of the currents (the factor most strongly emphasized by Meek). *Thus it is essential for fish with denatant pelagic larvae, inhabiting a region like the Patagonian Continental Shelf, where the main current flows from south to north, to spawn near the southern limit of their range (or so close inshore that the larvae are drifted by the inshore counter current to the southward) if the species is to be maintained within its ecological norm (cf.* E. S. Russell, 1937, p. 321). *A considerable meridional trend of seasonal movement may thus be superimposed upon the on- and offshore movement, and may even almost completely mask the latter.*

Considerable meridional trends of movement are shown by such fishes as *Stromateus*, *Macruronus* and *Genypterus* in the Patagonian region. With *Stromateus* such trends are superimposed upon a strong on- and offshore movement of the usual type, and seem almost certainly to be conditioned by the currents as outlined above. *Macruronus* gave more indications of meridional than of on- and offshore movement, and this may be partly due to its marked preference[1] for moderate depths of water. Some tendency to offshore movement was discernible, but the fish was never plentiful at such great depths as those in which true hake are sometimes captured. It is very much a fish of the plain of the shelf, and even the largest individuals rarely seemed to go far 'over the edge'. Since *Macruronus* seems to spawn in early summer, the southward movement cannot be regarded as a breeding migration. It is perhaps a feeding migration, in which shoals of Falkland herring are the attraction. (Our largest concentrations of this species were discovered near the southern limits of its range early in autumn.) With *Genypterus* different factors are probably involved. The area investigated is probably south of the main habitat of the species. Our catches certainly suggest an ellipsoidal path of movement similar to that found in *Stromateus*, but the individuals concerned should probably be regarded as straggling adolescents, and considerations of the necessity for contranatant movement before spawning do not arise if this view is correct.

The coastal elasmobranch *Callorhynchus* showed evidence of southward movement in summer. It keeps so close to the 80 m. line (limit of the 'first slope') that such progress would be aided by the inshore counter-current, but it may well be that temperature is the more important factor here. We do not yet know where this species breeds.

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[1] Using a teleological expression, in the interests of clarity and brevity.

Demersal fishes of extensive depth range tend to show larger individuals in deeper water, except when this tendency may temporarily be masked by seasonal movements. A similar tendency can sometimes be discerned interspecifically, but there are many obvious exceptions (such as large, exclusively littoral species) if purely taxonomic units are considered.

Most of the fish for which we have any adequate data demonstrate the first (intra-specific) part of this proposition very clearly. The second part is also clear when sufficient data are to hand to permit ecological rather than taxonomic groupings to be considered, and is very well shown by the depth relations of Patagonian Nototheniiformes.

Fishes of wide latitudinal range often show a gradation of size with latitude, the individuals being larger towards the polar limits of the range of the species. This implies either that the stocks are different in different latitudes (with different spawning times) as has been shown for European hake; or that only the larger individuals penetrate towards the polar limits of the range of the species.

The first type of correlation between size and latitude seems to be exemplified by our Patagonian hake, which consistently showed larger fishes as one proceeded south, but in the movements of which little meridional trend could be detected. But to the extreme south of the species' range only a very few outsize female individuals were taken. These can hardly be a breeding stock and are thought to be exceptionally aged individuals that may have lost the seasonal urge to migration through reduced reproductive activity.

Macruronus also showed the largest individuals to the southward *at most seasons*, but with this species a considerable meridional trend of movement seems certain, so that the size latitude correlation is probably a transient one, consequent upon the greater speed and strength of the larger fish, which may enable them to proceed farther afield in the search for food.

In many fishes a marked change in diet occurs with increasing size (age). Often this may coincide with the attainment of sexual maturity and or greatly increased migrations (cf. Harold Thompson, 1943, p. 86, *on Newfoundland Cod*; Hartley, 1945, pp. 11, 26, *on British fresh-water fish*).

This change of diet is very well shown by the larger species of the shelf, *Macruronus* and hake. The smaller individuals seem to feed mainly upon macroplanktonic Crustacea, the larger ones upon fish and squids. Of the more definitely bottom-feeding species it is practically certain that *Notothenia ramsayi* will be found to show an analogous change, from a diet of mysids, benthic Crustacea and polychaetes to one of larger prey—fish, especially Falkland herring. Our data are insufficient to establish the point beyond question. The probable coincidence of change in feeding habits with onset of sexual maturity and increased migration is particularly well shown by *Macruronus*.

In a large majority of fishes, females are larger than males; and this is usually sufficient to account for the slight abnormalities of sex-ratio (preponderance of females) commonly encountered in net-caught samples. Marked abnormalities in this or the other direction are usually due to peculiar seasonal trends towards unisexual shoaling, and are well known in certain elasmobranchs.

Nearly all the Patagonian species for which we have adequate data showed the females to be larger than the males. Usually the difference was small but strongly significant. The single possible exception to this 'rule' was *Cottoperca gobio* (Bovichthyidae) where the males *seemed* to be the larger. More data would probably dispel this apparent anomaly. The Patagonian hake (*Merluccius hubbsi*) shows a most unusual discrepancy in size between the sexes, the males being very much smaller than the females (much more so than in European hake). With a few species strongly abnormal sex-ratios were encountered that suggest possibilities of unisexual shoaling (Macruridae, *Micromesistius australis*).

PROSPECTS OF COMMERCIAL DEVELOPMENT

THE WEIGHT OF CATCHES

The best basis for any consideration of the possibilities of developing commercial fisheries in the area surveyed is the weight data collected in 1930–1. In the endeavour to present this intelligibly but at the same time in sufficiently concise form, I have divided the entire contents of all roughly comparable hauls for which weight data are available into the categories shown below, with brief notes on which each represents:

Categories employed in further considerations of weight data	Notes
Elasmobranchii	Since dogfish are rare, this category consists almost entirely of the small rays and skates of the region, with a few *Callorhynchus* at some inshore stations. **Not important**
Merluccius	Hake (*Merluccius hubbsi*), smaller than the European species and nearest to *M. bilinearis*, the 'whiting' of New England. **Very important**, and would be the staple of any trawling on the shelf that could be developed
Macruronus	'Long-tailed hake' *Macruronus magellanicus*, allied to the true hake. Its 'rat-tailed' appearance might be against it, but it is very good eating and locally abundant at times. **Important**
Gadidae	Here comprise only *Salilota*, *Micromesistius* (roughly equivalent to the 'Scotch haddock' or 'forked hake' and the 'blue whiting' of British seas), and a few tiny *Physiculus*. **Not important**
Nototheniiformes	The large southern group characteristic of the region, where they correspond ecologically to the smaller 'rock-fishes' of the eastern North Pacific. Mostly too small to be of value as human food. *Notothenia ramsayi*, the principal trawled species, is sometimes so abundant that it might be used for fish-meal if a fishery could be established on the more valuable categories. **Unimportant**, except as forage for hake, etc. *Eleginops* may prove useful in small-scale inshore fishing, but was not trawled
Thyrsites	*Thyrsites atun*, the 'snoek' of South Africa, 'barracouta' of Australia. Properly an inhabitant of warmer seas; such stragglers as are taken off Patagonia would always be valuable for they are excellent food fish, but are **too rare** for the species to be considered potentially important here
Genypterus	*Genypterus blacodes*, excellent food fish (the 'ling' of New Zealand, and very close to the 'king-klip' of South Africa) but probably **too rare** to be important here
Stromateus	'Spotted pomfret', *Stromateus maculatus*, close to the 'butterfish' of eastern U.S.A. and the 'silvery pomfret' of China. A very good food fish, locally abundant in due season. **Important**
Other fishes	**Unimportant**, though the minute 'scald-fish' *Thysanopsetta* was numerically abundant in the intermediate region and is eaten by hake. Such odd herrings and rattails (Macruridae) as are included in this category, chiefly in the southern region, could be utilized
Total fish	Useful for comparisons of the relative potential of the three regions, and the relative amounts of rubbish present
Lithodes	*Lithodes antarcticus*, one of the more abundant of the larger invertebrates, and prized as food in South America, where they are known as 'Centolla crabs'. Of **some** potential value
Squids	Several species. Some are eaten in South America, and they would be valuable as bait if any line fishing were developed. Important as food for some of the larger fish
'Rubbish'	The remaining contents of the trawl—invertebrates of no foreseeable value, sand, stones, etc. Of considerable **negative importance**, indicating where the greatest loss through damage to gear and time spent in sorting may be expected in any fishery that might be developed

It is imperative to bear in mind that *a commercial vessel, fishing with similar gear in the same area as that surveyed by the 'William Scoresby', could reckon on much better catches.* A surveying vessel needs to cover and re-cover as much ground as possible, for from the point of view of the survey it is just as important to determine where and when the fish are *not* to be found, as it is to find out where they *are*. A commercial vessel, on the other hand, will continue to work as long as possible wherever the fishing seems best. Consequently it is safe to assume that a commercial vessel would average far greater weights of fish per hour's trawling—probably at least twice as great—as did the 'Scoresby'.

In the **northern region** we have roughly comparable data from fourteen hauls, totalling 23 hr. fishing. The abstracted weight analysis is shown in Table 40.

Table 40. *Analysis of abstracted weight data from the northern region*

Hauls considered: WS788, 789, 790A, 790B (4 hr.), 791A, 791B (4 hr.), 792A, 792B (4 hr.), 793, 853, 855, 859A, 859B, 858.

Category	Presence	% occurrence	Total weight kg.	% of total weight (of fish only)	Weight per hour's trawling kg.	Weight per hour as %
Elasmobranchii	10/14	71·4	26·498	1·74	1·152	1·63
Merluccius	14/14	100·0	1260·795	82·84	54·817	77·57
Macruronus	13/14	92·8	188·900	12·41	8·213	11·62
Gadidae	4/14	28·6	0·520	0·04	0·023	0·03
Nototheniiformes	13/14	92·8	19·360	1·27	0·842	1·19
Thyrsites	0/14	0·0	0·000	0·00	0·000	0·00
Genypterus	3/14	22·2	1·800	0·12	0·078	0·11
Stromateus	10/14	71·4	16·589	1·09	0·721	1·02
Other fishes	10/14	71·4	7·438	0·49	0·323	0·46
Total fishes	14/14	100·0	1521·916	100·00	66·170	93·63
Lithodes	11/14	78·6	33·725	—	1·466	2·07
Squids	10/14	71·4	23·983*	—	1·043	1·48
Rubbish	13/14	92·8	45·858 + †	—	1·994	2·82

* Calculated from six weighing out of ten stations at which squids were caught.

† Calculated from twelve weighings out of thirteen stations at which rubbish was present.

A hake fishery in this region might just show a profit if markets comparable to those in Europe were available. The 'William Scoresby' obtained an average of just over 1 cwt. (51 kg.) of hake per hour. A commercial vessel could reasonably expect to catch twice as much, and an experienced skipper, Capt. Drennan, quoted by Hickling (1927, p. 10) has estimated that some 150 cwt. per 100 hr. was the minimum necessary to enable a big trawler to pay her way. There was, however, very little in the rest of the catch here to supplement the hake, and though relative absence of 'rubbish' would make for few repairs and easy sorting, we have to remember that these hake are smaller than the European species. Most of them might correspond to (say) 'inters' at Milford Haven or 'ordinary chats' at Fleetwood. Very few would equal the larger British trade categories. The big difficulty, of course, which at present appears insurmountable, is the absence of a suitable market.

From the **intermediate region** there are data from twenty-nine hauls totalling 44 hr. trawling, shown in Table 41.

Here the prospects are very poor, for less than half the weight of hake per hour that we had captured in the northern region was taken, and a slight increase of *Stromateus* and *Genypterus* among the better sorts was far too small to compensate for the shortage of hake. Moreover, a ruinous amount of rubbish came up in the trawl here.

In the **southern region** data are available from forty hauls, totalling 60 hr. trawling, shown in Table 42.

Here there were even fewer hake, but they included all the largest individuals of the species that we captured, as can be seen from the detailed figures discussed elsewhere. Two of the best of the other categories, *Macruronus* and *Stromateus*, showed their greatest relative abundance in this region. These were both much more concentrated locally than the hake, so that commercial vessels seeking them could be sure of far greater quantities than we captured while trying to sample the whole area. Several categories—Gadidae, Nototheniiformes and *Thyrsites*—showed greater abundance in this region (and individuals of greater size). Though the total quantities of these are very small they would all help to eke out catches of the more plentiful species. Even the 'Other fishes' here include species that could be utilized, e.g. herring and Macrurids. However, it cannot be said that the trawling prospects were at all encouraging, taking the southern region as a whole. The proportion of rubbish that came up in the trawl was nearly as great as in the intermediate region, and prevalence of foul ground leads to much time lost in mending nets, apart from loss of gear through occasional serious damage. Of this our field workers had bitter experience.

Table 41. *Analysis of abstracted weight data, intermediate region*

Hauls considered: WS773, 774, 775, 776, 784, 785A, 785B, 785C, 786, 794, 795, 796A, 796B (4 hr.), 797B, 797C (4 hr.), 798, 799A, 799B (4 hr.), 800A, 800B (4 hr.), 801, 807, 808, 809A, 809B (4 hr.), 810, 857, 862, 864.

Category	Presence	% occurrence	Total weight kg.	% of total weight (of fish only)	Weight per hour's trawling kg.	Weight per hour as %
Elasmobranchii	18/29	62·1	24·186	2·04	0·550	1·28
Merluccius	26/29	89·7	853·540	71·95	19·399	45·03
Macruronus	15/29	51·7	162·730	13·72	3·698	8·58
Gadidae	11/29	37·9	11·430	0·96	0·260	0·60
Nototheniiformes	28/29	96·6	52·478	4·42	1·193	2·77
Thyrsites	0/29	0·0	0·000	0·00	0·000	0·00
Genypterus	7/29	24·1	12·355	1·04	0·280	0·65
Stromateus	15/29	51·7	55·570	4·68	1·263	2·93
Other fishes	18/29	62·1	14·004	1·18	0·318	0·74
Total fishes	29/29	—	1186·293	99·99	26·961	62·58
Lithodes	16/29	55·2	39·957*	—	0·908	2·11
Squids	27/29	93·1	56·344†	—	1·280	2·97
Rubbish	29/29	100·0	613·031 + ‡	—	13·932	32·44

* Calculated from fifteen weighings out of sixteen hauls containing Lithodes.
† Calculated from fifteen weighings out of twenty-seven hauls containing squids.
‡ Calculated from twenty-eight weighings out of twenty-nine hauls containing rubbish.

Table 42. *Analysis of abstracted weight data, southern region*

Hauls considered: WS802A, 802B, 803, 804A, 804B, 805, 806, 811I, 811II (4 hr.), 812I, 812II (4 hr.), 813, 814, 815, 816, 817A, 817B (4 hr.), 818A, 818B (4 hr.), 819A, 819B (4 hr.), 820, 824, 825, 833, 834, 838, 839, 847A, 847B (4 hr.), 848, 849, 850, 851, 866, 868, 870, 872, 874, 875.

Category	Presence	% occurrence	Total weight kg.	% of total weight (of fish only)	Weight per hour's trawling kg.	Weight per hour as %
Elasmobranchii	20/40	50·0	54·115	2·00	0·902	1·34
Merluccius	26/40	65·0	447·860	16·55	7·464	11·07
Macruronus	21/40	52·5	1257·435	46·48	20·957	31·08
Gadidae	29/40	72·5	258·367	9·55	4·306	6·39
Nototheniiformes	34/40	85·0	89·374	3·30	1·484	2·20
Thyrsites	5/40	12·5	158·000	5·84	2·633	3·90
Genypterus	9/40	22·5	14·070	0·52	0·234	0·35
Stromateus	19/40	47·5	256·750	9·49	4·279	6·35
Other fishes	28/40	70·0	169·546	6·27	2·826	4·24
Total fishes	—	—	2705·517	100·00	45·085	66·86
Lithodes	21/40	52·5	68·184*	—	1·136	1·68
Squids	21/40	52·5	77·215†	—	1·287	1·91
Rubbish	40/40	100·0	1195·443‡	—	19·924	29·55

* Calculated from twenty weighings out of the twenty-one hauls in which *Lithodes* was taken.
† Calculated from seventeen weighings out of the twenty-one hauls in which squids were taken.
‡ Calculated from thirty-eight weighings out of the forty hauls.

A reshuffling of these weight data, with the addition of corresponding numerical values for the fish categories, is given in Tables 43 and 44. These permit direct comparison and contrast of the three regions, considered as possible fishing grounds; but for a full appreciation of the possible implications of these, the reader must refer to the general account of the region given in the introduction, and to the individual accounts of the more important species given in the body of the paper. It is hoped that the table of contents will make it possible to do this without the necessity for reading through the whole report.

Table 43. *Further analysis of weight data: occurrence, relative numbers and relative weights of the main fish categories in each of the three regions*

Main categories of the fish fauna	Frequency of occurrence (% of hauls positive)			% by numbers of each category of totals for each region			% by weight of each category of total weight for each region		
	N. region	I. region	S. region	N. region	I. region	S. region	N. region	I. region	S. region
Elasmobranchii	**71·4**	62·1	*50·0*	**0·87**	2·82	*1·38*	**1·74**	2·04	*2·00*
Merluccius	**100·0**	89·7	*65·0*	**47·00**	23·21	*7·47*	**82·84**	71·95	*16·55*
Macruronus	**92·8**	51·7	*52·5*	**23·61**	16·93	*47·32*	**12·41**	13·72	*46·48*
Gadidae	**28·6**	37·9	*72·5*	**0·24**	2·23	*12·47*	**0·04**	0·96	*9·55*
Nototheniiformes	**92·8**	96·6	*85·0*	**26·01**	19·44	*9·23*	**1·27**	4·42	*3·30*
Thyrsites	—	—	*12·5*	—	—	*0·82*	—	—	*5·84*
Genypterus	**22·2**	24·1	*22·5*	**0·10**	0·33	*0·22*	**0·12**	1·04	*0·52*
Stromateus	**71·4**	51·7	*47·5*	**1·14**	4·81	*13·28*	**1·09**	4·68	*9·49*
Other fish	**71·4**	62·1	*70·0*	**1·02**	30·23	*7·81*	**0·49**	1·18	*6·27*

Table 44. *Further analysis of weight data: mean numbers, mean weights and relative weights per hour's trawling of the main categories, in each of the three regions*

Main categories of fish, extras and rubbish per hour's trawling	Mean numbers of fish (per hour's trawling)			Mean weight of fish, etc., per hour's trawling (kg.)			% by weight per hour's trawling of fish, extras and rubbish		
	N. region	I. region	S. region	N. region	I. region	S. region	N. region	I. region	S. region
Elasmobranchii	**1·87**	2·50	*1·23*	**1·152**	0·550	*0·902*	**1·63**	1·28	*1·34*
Merluccius	**100·48**	20·59	*6·67*	**54·817**	19·399	*7·464*	**77·57**	45·03	*11·07*
Macruronus	**50·48**	15·02	*42·23*	**8·213**	3·698	*20·957*	**11·62**	8·58	*31·08*
Gadidae	**0·52**	1·98	*11·13*	**0·023**	0·260	*4·306*	**0·03**	0·60	*6·39*
Nototheniiformes	**55·61**	17·25	*8·23*	**0·842**	1·193	*1·484*	**1·19**	2·77	*2·20*
Thyrsites	—	—	*0·73*	—	—	*2·633*	—	—	*3·90*
Genypterus	**0·22**	0·30	*0·20*	**0·078**	0·280	*0·234*	**0·11**	0·65	*0·35*
Stromateus	**2·43**	4·27	*11·85*	**0·721**	1·263	*4·279*	**1·02**	2·93	*6·35*
Other fish	**2·17***	26·82†	*6·97*‡	**0·323**	0·318	*2·826*	**0·46**	0·74	*4·24*
Total fish	**213·78**	88·73	*89·24*	**66·170**	26·961	*45·089*	**93·63**	62·58	*66·86*
Lithodes	—	—	—	**1·466**	0·908	*1·136*	**2·07**	2·11	*1·68*
Squids	—	—	—	**1·043**	1·208	*1·287*	**1·48**	2·97	*1·91*
Rubbish	—	—	—	**1·994**	13·932	*19·924*	**2·82**	32·44	*29·55*

* Almost negligible in northern region except for *Palinuricthys* (useful) at one station.

† Mainly large numbers of the tiny flatfish *Thysanopsetta*, too small to be of value.

‡ Of some importance in the southern region—sizeable Macrurids, Falkland herring, *Parona signata*.

CONCLUSIONS

In the exploration of natural resources the primary function of the naturalist is to provide fundamental information on the nature, quantity and accessibility of the raw material. Thereafter the administrator and technologist are in a better position to assess the prospects of commercial development. It is felt, however, that a report such as this would be incomplete without some practical suggestions from those who have collected and collated the biological data. In the remarks which follow, I am confident that where our evidence is already good, the opinions expressed are shared by colleagues who were directly engaged in collection of the data at sea. The more tentative suggestions are my own (T. J. H.).

The primary object of these investigations was to provide information, upon which the prospects of carrying on any commercial fishery from the Falkland Islands could be assessed. It must be plainly stated that the results are not encouraging; but this is due to economic and geographical factors, rather than to lack of suitable fish. The best trawling grounds are not very near to the Falkland Islands, but it can be shown with reasonable certainty that on the shelf to the northward, roughly equidistant from the Falkland Islands and the lesser Argentine ports, there is a stock of hake just sufficient to enable a modern trawler to pay its way *if there were markets equivalent to the British ones within a few hundred miles.*

The population of the Falkland Islands is too small and too scattered (with limited means of communication between the settlements) to enable a large trawler to pay its way on local trade alone. If a considerable part of the catch could be sold in, for example, the Argentine at a reasonable price, a trawler working from Port Stanley might be able to keep the latter supplied with the results of, say, one voyage in four. The possibilities of smoking, drying and dehydration would no doubt be taken into consideration, but it seems doubtful whether the fish could be marketed at an economic price in the Argentine. However, I venture to suggest three possibilities, on the strength of the knowledge of the fish-fauna that we have gained.

I. Local inshore seining for 'mullet' (*Eleginops*), 'smelts' (*Austromenidia*) and such other species as present themselves. Dr Kemp informed me shortly before his death that our former colleague Dr J. E. Hamilton was even then trying to establish some inshore fishery in the Falklands. Much might be done to place such a scheme on a permanent footing if a small-scale canning plant could be established. This could deal with an occasional glut of 'herring' (*Clupea fuegensis*) but might aim primarily at developing a small luxury trade in canned Centolla crab (*Lithodes*), serving to keep a few hands permanently employed. It is not yet known for certain that these crabs would be accessible in sufficient quantity to small coastal craft, but we found encouraging numbers of them in the trawl on the rough ground round the islands, that would not support ordinary inshore trawling. The main part of this scheme would aim at providing some fresh fish for local consumption (a real need). The canning is a further suggestion to aid in keeping it on a self-supporting basis, which could hardly be hoped for from small-scale seining alone.

II. Exploitation of *Clupea fuegensis*, possibly by some form of purse-seining, for drift nets or other forms of gill-nets would almost certainly suffer too much from damage by seals and birds to make them workable in the Falkland area. Such a scheme would depend upon canning, production of fish-meal or other means of processing the product. As already explained the trawl could not provide adequate evidence of the quantities of these small semi-pelagic fish available, so that further, possibly costly investigations would be needed, before one could form an adequate opinion as to the feasibility of such a scheme.

III. Part-time trawling. If a cold store were available in Port Stanley, and if sufficient employment could be found for a suitable vessel (possibly on inter-island communications) during more than half her time, a modern trawler occasionally working the hake grounds we found to the north could easily keep Port Stanley on a full supply of fish; but it is very doubtful whether she would pay her way at this.

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APPENDICES

APPENDIX I. PARTICULARS OF TRAWLING STATIONS

Station (region indicated by type as in text)	Date	Position		Time: duration of trawl		Depth m.	Distance from mainland (sea miles)	Distance from Falkland Islands (where < 100 miles)	Temperature °C.		Notes
		Lat. S	Long. W	From	To				Surface	Bottom	
WS71	23. ii. 27	51° 38′	57° 32½′	1410	1514	82–80	340	8	9·24	7·76	—
WS72	5. iii. 27	51° 07′	57° 34′	1520	1550	79–79	359	20	8·51	7·38	—
WS73	6. iii. 27	51° 02′	58° 55′	1915	2010	121	324	10	9·38	6·71	—
WS75	10. iii. 27	51° 00′	60° 31′	1742	1834	72	288	10	9·63	8·16	—
WS76	11. iii. 27	51° 00′	62° 03′	1404	1453	207–205	226	20	9·44	5·91	—
WS77	12. iii. 27	51° 01′	66° 31½′	1035	1132	110–113	179	> 100	9·77	8·30	—
WS78	13. iii. 27	51° 01′	68° 04½′	1845	1945	95–91	41	> 100	10·32	7·86	—
WS79	13. iii. 27	51° 01½′	64° 59½′	2015	2115	132–131	126	> 100	9·26	7·83	—
WS80	14. iii. 27	50° 57′	63° 37½′	1901	2005	152–156	170	78	9·21	6·77	—
WS81	19. iii. 27	51° 30′	61° 12½′	1905	2002	81–82	268	11	8·90	8·22	—
WS82	21. iii. 27	54° 06′	57° 47′	1718	1750	140–144	288	91	6·64	6·62	OTC not fishing properly
WS83	24. iii. 27	52° 29′	60° 07¾′	1125	1225	137–129	232	13	8·43	7·60	—
WS84	24. iii. 27	52° 33¾′	59° 09½′	1710	1815	75–74	259	6	8·23	8·20	Net torn
WS85	25. iii. 27	52° 08½′	58° 11½′	1715	1815	79–79	304	12	8·38	8·30	—
WS86	3. iv. 27	53° 53½′	60° 34½′	0755	0858	151–147	176	78	7·09	6·82	Net torn
WS87	3. iv. 27	54° 07½′	58° 16′	1815	1910	96–127	258	83	6·67	6·77	—
WS88	6. iv. 27	54° 00′	64° 57½′	1608	1713	118–118	45	> 100	8·81	8·18	—
WS89	7. iv. 27	53° 00′	68° 06½′	1130	1205	23–21	7	> 100	9·29	9·27	—
WS90	7. iv. 27	52° 19′	67° 58½′	1752	1852	82–81	16	> 100	9·07	8·86	—
WS91	8. iv. 27	52° 54′	64° 37½′	0800	0916	191–205	114	> 100	8·32	7·34	—
WS92	8. iv. 27	51° 58½′	65° 01′	1515	1617	145–143	125	> 100	8·80	8·17	—
WS93	9. iv. 27	51° 58½′	61° 15′	1750	1852	133–130	266	4	8·16	7·30	Net torn
WS94	16. iv. 27	50° 00¼′	64° 57½′	1947	2047	110–126	107	> 100	8·48	7·95	—
WS95	17. iv. 27	48° 58′	64° 45′	0615	0720	109–108	68	> 100	9·70	8·33	—
WS96	17. iv. 27	48° 01′	64° 58′	1553	1653	96–96	34	> 100	10·41	10·04	—
WS97	18. iv. 27	49° 00½′	61° 58′	0620	0730	146–145	165	> 100	8·90	6·41	—
WS98	18. iv. 27	49° 54′	60° 35½′	1645	1755	173–171	238	69	9·09	5·31	—
WS99	19. iv. 27	49° 42′	59° 14½′	0605	0710	251–225	285	87	8·25	5·94	—
WS108	25. iv. 27	48° 31′	63° 34′	1658	1759	118–120	94	> 100	9·29	6·92	—
WS109	26. iv. 27	50° 18′	58° 28½′	1713	1813	145	349	57	—	—	—
WS210	29. v. 28	50° 17′	60° 06′	1015	1040	161–174	289	52	6·55	—	OTC, not fishing properly
WS211	29. v. 28	50° 17′	60° 06′	1217	1325	174	289	52	6·59	5·58	—
WS212	30. v. 28	49° 22′	60° 10′	1055	1155	242–249	231	> 100	6·50	5·84	Net fouled
WS213	30. v. 28	49° 22′	60° 10′	1430	1545	242–239	231	> 100	6·45	5·59	—
WS214	31. v. 28	48° 25′	60° 40′	0910	1010	208–219	199	> 100	6·67	5·54	—
WS215	31. v. 28	47° 37′	60° 50′	1600	1700	219–146	194	> 100	6·67	5·89	Fouled, fish caught in wings
WS216	1. vi. 28	47° 37′	60° 50′	0830	0935	219–133	197	> 100	6·67	5·79	—
WS217	1. vi. 28	46° 28′	60° 18′	1635	1735	146–146	221	> 100	7·03	6·39	—
WS218	2. vi. 28	45° 45′	59° 35′	0820	0920	311–247	269	> 100	6·49	4·99	—
WS219	3. vi. 28	47° 06′	62° 12′	0817	0917	116–114	134	> 100	7·60	7·56	—
WS220	3. vi. 28	47° 56′	62° 38′	1608	1710	108–104	126	> 100	7·55	7·81	—
WS221	4. vi. 28	47° 23′	65° 10′	0835	0935	76–91	24	> 100	8·15	8·22	Net fouled
WS222	8. vi. 28	47° 23′	65° 00′	0755	0857	100–106	29	> 100	8·05	8·12	—
WS223	8. vi. 28	49° 13′	64° 08′	1541	1646	114–114	95	> 100	7·23	7·13	—

Station (region indicated by type as in text)	Date	Position		Time: duration of trawl		Depth m.	Distance from mainland (sea miles)	Distance from Falkland Islands (where < 100 miles)	Temperature ° C.		Notes
		Lat. S	Long. W	From	To				Surface	Bottom	
WS224	9. vi. 28	50° 18′	59° 58′	1920	2037	124–126	294	52	7·35	7·41	—
WS225	9. vi. 28	50° 20′	59° 30′	2150	2256	162–161	273	54	6·85	6·84	—
WS226	10. vi. 28	49° 20′	62° 30′	0820	0921	144–152	155	> 100	6·86	6·91	—
WS227	12. vi. 28	51° 08′	56° 50′	0754	0859	320–295	382	40	5·78	4·56	—
WS228	30. vi. 28	50° 50′	56° 58′	0828	0928	229–236	389	48	5·34	5·14	Net fouled
WS229	1. vii. 28	50° 35′	57° 20′	1100	1200	210–271	384	51	5·39	5·31	—
WS230	3. vii. 28	50° 10′	58° 42′	1350	1450	169–167	356	66	5·75	5·71	Net fouled
WS231	4. vii. 28	50° 10′	58° 42′	0826	0931	167–159	356	66	5·95	5·81	—
WS232	5. vii. 28	49° 25′	59° 45′	0755	0855	198–190	247	> 100	5·88	5·65	Net fouled
WS233	5. vii. 28	49° 25′	59° 45′	1134	1234	185–175	247	> 100	5·79	5·63	—
WS234	5. vii. 28	48° 52′	60° 25′	1750	1850	195–207	215	> 100	5·94	5·66	—
WS235	6. vii. 28	47° 56′	61° 10′	0755	0855	155–155	178	> 100	6·23	5·60	—
WS236	6. vii. 28	46° 55′	60° 40′	1608	1708	272–300	167	> 100	6·07	4·91	—
WS237	7. vii. 28	46° 00′	60° 05′	1055	1155	150–256	217	> 100	6·19	5·29	—
WS238	8. vii. 28	48° 30′	61° 50′	0932	1032	—	—	—	6·41	6·41	Net torn from footrope
WS239	15. vii. 28	51° 10′	62° 10′	1708	1811	196–193	226	25	5·91	5·68	—
WS240	16. vii. 28	51° 55′	65° 10′	0942	0944	144–141	—	—	5·60	5·61	Net fouled
WS241	16. vii. 28	51° 55′	65° 10′	1522	1624	143–157	—	—	—	—	Net fouled
WS242	17. vii. 28	51° 06′	66° 30′	0740	0841	119–119	86	> 100	6·23	6·24	—
WS243	17. vii. 28	51° 06′	64° 30′	1616	1716	144–141	151	> 100	5·91	5·91	—
WS244	18. vii. 28	52° 00′	62° 40′	0813	0913	253–247	214	50	5·67	5·31	—
WS245	18. vii. 28	52° 36′	63° 40′	1705	1810	304–290	141	> 100	5·91	5·27	—
WS246	19. vii. 28	52° 25′	61° 00′	1015	1115	267–208	210	14	5·24	5·53	—
WS248	20. vii. 28	52° 40′	58° 30′	0750	0850	210–242	285	25	5·13	5·21	—
WS250	20. vii. 28	51° 45′	57° 00′	1944	2047	251–313	356	27	5·09	4·61	—
WS756A	10. x. 31	50° 56′	59° 56′	1028	1130	118–104	278	16	4·32	4·02	—
WS756B	10. x. 31	50° 56′	59° 56′	1435	1545	104–90	278	16	—	—	Net torn
WS762A	16. x. 31	43° 51½′	65° 03′	0720	0830	67–65	14	> 100	8·60	8·60	—
WS762B	16. x. 31	43° 48½′	65° 00′	0910	1010	67–65	10	> 100	—	—	—
WS763	16. x. 31	44° 14½′	63° 30′	1925	2030	87–82	75	> 100	8·44	6·59	—
WS764A	17. x. 31	44° 36½′	61° 57′	0720	0830	106–110	145	> 100	7·51	6·09	—
WS764B	17. x. 31	44° 40′	62° 00′	0915	1015	110–104	140	> 100	—	—	—
WS765	17. x. 31	45° 06′	60° 30′	1845	1950	113–118	212	> 100	6·78	5·52	—
WS771	29. x. 31	42° 40′	62° 32′	1730	1830	90–90	130	> 100	10·11	6·27	—
WS772	30. x. 31	45° 13′	60° 00′	1630	1645	309–162	231	> 100	7·90	4·59	Short haul
WS773	31. x. 31	47° 27′	60° 49′	1423	1523	291–298	206	> 100	6·82	4·77	Net torn but fished well
WS774	1. xi. 31	47° 09′	62° 00′	1730	1830	139–144	148	> 100	8·00	6·23	—
WS775	2. xi. 31	46° 44½′	63° 30′	1620	1720	115–110	82	> 100	7·99	6·18	—
WS776	3. xi. 31	46° 19′	65° 00′	0625	0725	107–99	60	> 100	8·50	7·57	—
WS777	3. xi. 31	45° 56′	66° 24′	1830	1930	98–99	43	> 100	9·75	7·52	Trawl torn
WS781	6. xi. 31	50° 29′	58° 52′	1800	1920	148–?	297	41	5·58	4·78	Many sponges
WS782A	4. xii. 31	50° 30′	58° 19′	0725	0825	141–146	313	48	7·30	5·14	—
WS782B	4. xii. 31	50° 30′	58° 19′	1020	1120	141–146	307	49	—	—	—
WS783	5. xii. 31	50° 03½′	60° 08′	0805	0910	155–159	338	66	8·04	4·89	—

APPENDIX I (*cont.*)

Station (region indicated by type as in text)	Date	Position		Time: duration of trawl		Depth m.	Distance from mainland (sea miles)	Distance from Falkland Islands (where < 100 miles)	Temperature C.		Notes
		Lat. S	Long. W	From	To				Surface	Bottom	
WS784	5. xii. 31	49° 48½′	61° 03′	1735	1835	170–164	208	75	8·05	4·82	—
WS785A	6. xii. 31	49° 26½′	62° 34′	1010	1110	150–147	151	100	8·78	5·72	—
WS785B	6. xii. 31	49° 25′	62° 37½′	1150	1250	150–147	143	> 100	—	—	—
WS785C	6. xii. 31	49° 23½′	62° 41′	1330	1430	150–147	140	> 100	—	—	—
WS786	7. xii. 31	49° 07′	63° 55′	0520	0630	133–119	96	> 100	8·39	6·34	—
WS787	7. xii. 31	48° 44′	65° 24½′	1615	1715	106–110	39	> 100	9·56	7·35	—
WS788	13. xii. 31	45° 05′	65° 00′	1755	1855	82–88	27	> 100	13·45	9·70	—
WS789	13. xii. 31	45° 17′	64° 22′	2227	2343	95–93	53	> 100	13·78	7·12	—
WS790A	14. xii. 31	45° 28¼′	63° 42¼′	0625	0730	99–101	85	> 100	13·11	7·14	—
WS790B	14. xii. 31	45° 28¼′	63° 42¼′	0835	1240	99–101	85	> 100	—	—	—
WS791A	14. xii. 31	45° 38′	62° 57′	1600	1700	97–96	121	> 100	13·62	6·52	—
WS791B	14. xii. 31	45° 41′	62° 45′	1950	2350	96–101	125	> 100	—	—	—
WS792A	15. xii. 31	45° 49′	62° 23′	0250	0350	102–106	145	> 100	13·10	6·43	—
WS792B	15. xii. 31	45° 52½′	62° 12′	0450	0850	106–112	149	> 100	—	—	—
WS793	16. xii. 31	45° 58′	61° 42′	0250	0350	108–111	175	> 100	13·15	6·52	—
WS794	17. xii. 31	46° 11¾′	61° 01′	0850	0950	123–126	188	> 100	11·20	6·07	—
WS795	18. xii. 31	46° 14′	60° 24′	1111	1211	157–161	211	> 100	9·28	4·83	—
WS796A	19. xii. 31	47° 50¾′	63° 40½′	1200	1300	106–113	80	> 100	14·41	7·33	—
WS796B	21. xii. 31	47° 51′	63° 43′	0350	0750	108–112	80	> 100	—	—	—
WS797A	19. xii. 31	47° 32′	65° 00′	1800	—?	—	30	> 100	10·37	7·57	Trawl fouled
WS797B	20. xii. 31	47° 44′	64° 22′	1712	1812	115–111	56	> 100	—	—	—
WS797C	20. xii. 31	47° 32′	65° 00′	2000	2355	111–114	29	> 100	—	—	—
WS798	20. xii. 31	47° 31½′	65° 02′	1142	1242	49–69	27	> 100	9·05	8·89	—
WS799A	21. xii. 31	48° 03½′	62° 50¼′	1207	1307	141–137	113	> 100	10·97	6·74	—
WS799B	21. xii. 31	48° 07½′	62° 23′	1345	1745	137–139	115	> 100	—	—	—
WS800A	21. xii. 31	48° 15′	62° 11¾′	2110	2210	139–137	139	> 100	9·90	—	—
WS800B	21/22. xii. 31	48° 19′	61° 58′	2250	0250	137–139	142	> 100	—	—	—
WS801	22. xii. 31	48° 25½′	61° 30′	0555	0655	165–165	167	> 100	9·33	—	—
WS802A	5. i. 32	50° 47′	61° 20′	1335	1447	128–132	248	14	—	—	—
WS802B	5. i. 32	50° 44′	61° 26′	1530	1630	132–139	242	16	—	—	—
WS803	5. i. 32	50° 34½′	62° 03½′	2245	2345	173–186	199	30	—	—	—
WS804A	6. i. 32	50° 23½′	62° 47′	0547	0647	150–143	173	64	—	—	—
WS804B	6. i. 32	50° 22′	62° 51′	0745	0845	143–150	169	67	—	—	—
WS805	6. i. 32	50° 11′	63° 27′	1645	1745	148–148	147	90	—	—	—
WS806	7. i. 32	50° 04′	64° 19′	0615	0715	129–122	125	> 100	—	—	—
WS807	7. i. 32	49° 51′	65° 01′	1240	1340	125–126	104	> 100	—	—	—
WS808	8. i. 32	49° 41′	65° 40′	0630	0735	110–107	77	> 100	—	—	—
WS809A	8. i. 32	49° 29′	66° 27′	1450	1555	107–104	52	> 100	—	—	—
WS809B	8. i. 32	49° 29′	66° 41′	1635	2035	104–100	45	> 100	—	—	—
WS810	9. i. 32	49° 15′	67° 08′	0200	0255	95–96	20	> 100	—	—	—
WS811 I	10. i. 32	51° 27′	68° 03′	0701	0801	98–98	37	> 100	—	—	—
WS811 II	12. i. 32	51° 22′	68° 03′	2000	0000	96–98	39	> 100	—	—	—
WS812 I	10. i. 32	51° 15½′	68° 54′	1320	1420	53–54	9	> 100	—	—	—
WS812 II	12. i. 32	51° 17′	68° 50′	1315	1715	43–84	12	> 100	—	—	—

Station (region indicated by type as in text)	Date	Position		Time: duration of trawl		Depth m.	Distance from mainland (sea miles)	Distance from Falkland Islands (where < 100 miles)	Temperature ° C.		Notes
		Lat. S	Long. W	From	To				Surface	Bottom	
WS813	13. i. 32	51° 34½′	67° 18½′	0400	0500	106–102	59	> 100	—	—	—
WS814	13. i. 32	51° 44½′	66° 38′	1350	1450	111–118	71	> 100	—	—	—
WS815	13. i. 32	51° 51′	65° 46′	2045	2145	132–162	100	> 100	—	—	—
WS816	14. i. 32	52° 09½′	64° 58′	1200	1300	150–150	128	> 100	—	—	—
WS817A	14. i. 32	52° 21′	64° 17′	1805	1905	191–202	150	> 100	—	—	—
WS817B	14. i. 32	52° 27′	64° 09′	1945	2345	202–238	152	> 100	—	—	Boards locked, small fish escaped
WS818A	17. i. 32	52° 30½′	63° 27′	0540	0640	272–278	150	92	—	—	—
WS818B	17. i. 32	52° 34½′	63° 12½′	0740	1140	278–284	152	91	—	—	—
WS819A	17. i. 32	52° 41¼′	62° 41′	1645	1745	312–329	154	70	—	—	—
WS819B	17. i. 32	52° 45′	62° 27½′	1835	2235	329–342	156	68	—	—	—
WS820	18. i. 32	52° 52½′	61° 53½′	0345	0450	351–367	166	58	—	—	—
WS821	18. i. 32	52° 55′	60° 57′	1120	1140	461–468	191	41	—	—	Net fouled twice
WS823	19. i. 32	52° 12½′	60° 02′	0630	0730	80–95	244	8	—	—	—
WS824	19. i. 32	52° 31′	58° 29′	2000	2105	146–137	285	20	—	—	—
WS825	28/29. i. 32	50° 50′	57° 13′	0035	0135	135–144	372	41	—	—	—
WS833	1. ii. 32	52° 28′	68° 00′	1800	1900	38–31	15	> 100	—	—	—
WS834	2. ii. 32	52° 57′	68° 07′	0625	0725	27–38	6	> 100	—	—	—
WS837	3. ii. 32	52° 48½′	66° 30′	1625	1725	98–102	70	> 100	—	—	—
WS838	5. ii. 32	53° 11′	65° 02′	1207	1307	148–159	92	> 100	—	—	—
WS839	5. ii. 32	53° 29½′	63° 31′	2207	2307	403–434	96	> 100	—	—	—
WS840	6. ii. 32	53° 51½′	61° 51½′	1015	1115	368–463	132	> 100	—	—	Trawl torn
WS841	6. ii. 32	54° 11′	60° 23′	1930	2040	109–120	178	90	—	—	Footrope parted
WS847A	9. ii. 32	50° 15′	67° 59′	0815	0915	51–56	13	> 100	—	—	—
WS847B	9. ii. 32	50° 18′	67° 54′	1020	1420	56–18	15	> 100	—	—	Net torn
WS848	10. ii. 32	50° 37′	66° 26′	1225	1325	115–117	71	> 100	—	—	Net torn (slightly)
WS849	10. ii. 32	50° 56½′	65° 00′	2045	2145	137–137	125	> 100	—	—	—
WS850	11. ii. 32	51° 18′	63° 31′	0730	0838	157–166	189	80	—	—	—
WS851	11. ii. 32	51° 39′	62° 02½′	1615	1715	221–197	220	23	—	—	—
WS853	21. iii. 32	44° 38′	64° 15′	1220	1320	90–90	44	> 100	—	—	—
WS855	22. iii. 32	45° 56′	64° 10′	1340	1440	115–110	80	> 100	—	—	—
WS857	23. iii. 32	47° 11′	64° 15′	1335	1435	122–124	59	> 100	—	—	—
WS858	24. iii. 32	45° 42′	60° 30′	1335	1435	132–123	212	> 100	—	—	—
WS859A	25. iii. 32	45° 14′	61° 56′	0750	0850	106–110	146	> 100	—	—	—
WS859B	25. iii. 32	45° 11′	62° 01½′	0932	1032	110–106	142	> 100	—	—	—
WS860	25. iii. 32	44° 53′	63° 30′	1930	2030	101–104	77	> 100	—	—	May not have fished properly
WS862	27. iii. 32	48° 23′	64° 15′	1335	1455	112–115	63	> 100	—	—	—
WS864	28. iii. 32	49° 31′	64° 15′	1155	1255	128–126	104	> 100	—	—	—
WS866	29. iii. 32	50° 36′	64° 15′	1258	1358	137–144	139	> 100	—	—	—
WS868	30. iii. 32	51° 45′	64° 16′	1340	1440	166–162	158	> 100	—	—	—
WS870	31. iii. 32	52° 49′	64° 15′	1400	1500	269–276	121	> 100	—	—	—
WS872	1. iv. 32	53° 49′	64° 15′	1605	1705	139–141	60	> 100	—	—	—
WS874	3. iv. 32	52° 35′	65° 17′	0910	1010	135–132	117	> 100	—	—	—
WS875	3. iv. 32	52° 35′	63° 50′	1555	1655	252–234	139	> 100	—	—	—

APPENDIX IIA. HAKE DATA: FIRST SURVEY

Station	Hake nos.			Mean length		Theoretical weight kg.	Probable minimum weight, kg.
	♂♂	♀♀	Total	♂♂	♀♀		
WS71	0	0	0	—	—	—	—
WS72	0	0	0	—	—	—	—
WS73	0	0	15 (juv.)	—	—	—	—
WS75	0	0	0	—	—	—	—
WS76	0	0	2 (juv.)	—	—	—	—
WS77	0	1	1	—	—	—	—
WS78	4	29	33	—	—	—	—
WS79	1	26	27	—	—	—	—
WS80	0	26	26	—	57·4	*32·350*	*26·500*
WS81	0	0	0	—	—	—	—
WS82	0	0	0	—	—	—	—
WS83	0	0	0	—	—	—	—
WS84	0	0	0	—	—	—	—
WS85	0	0	0	—	—	—	—
WS86	0	0	0	—	—	—	—
WS87	0	0	0	—	—	—	—
WS88	0	0	0	—	—	—	—
WS89	0	0	0	—	—	—	—
WS90	16	71	87	—	—	—	—
WS91	0	2	2	—	—	—	—
WS92	4	10	14	35·8	43·5	*9·205*	*7·550*
WS93	0	0	0	—	—	—	—
WS94	40	63	103	36·7	45·4	*53·410*	*43·800*
WS95	10	29	39	39·4	43·4	*20·255*	*16·600*
WS96	14	16	30	30·0	33·7	*6·790*	*5·570*
WS97	13	22	35	38·1	52·5	*25·960*	*21·290*
WS98	11	60	71	37·8	53·6	*65·840*	*53·990*
WS99	0	19	19	—	63·3	*31·325*	*25·690*
WS108	62	64	126	35·6	43·3	*54·205*	*44·450*
WS109	0	28	28	—	63·0	*45·510*	*37·320*

APPENDIX IIb. HAKE DATA: SECOND SURVEY

Station	Hake nos.			Mean length		Theoretical weight kg.	Probable minimum weight, kg.
	♂♂	♀♀	Total	♂♂	♀♀		
WS210	—	—	—	—	—	—	—
WS211	3	28	31	37·3	45·8	20·035	16·430
WS212	—	—	—	—	—	—	—
WS213	0	1	1	—	54·0	1·113	0·913
WS214	18	93	111	46·3	57·9	132·770	108·870
WS215	0	5	5	—	54·8	5·630	4·620
WS216	87	181	268	40·1	47·5	176·990	145·130
WS217	118	293	411	39·4	46·4	260·060	213·250
WS218	4	72	76	38·8	62·1	119·500	97·990
WS219	16	26	42	36·8	39·4	17·200	14·100
WS220	3	3	6	44·7	43·0	3·390	2·780
WS221	—	—	—	—	—	—	—
WS222	0	1	1	—	59·0	1·430	1·172
WS223	—	—	—	—	—	—	—
WS224	—	—	—	—	—	—	—
WS225	0	3	3	—	64·7	1·845	1·513
WS226	—	—	—	—	—	—	—
WS227	0	1	1	—	59·0	1·430	1·172
WS228	—	—	—	—	—	—	—
WS229	0	2	2	—	54·5	2·355	1·930
WS230	—	—	—	—	—	—	—
WS231	—	—	—	—	—	—	—
WS232	—	—	—	—	—	—	—
WS233	1	4	5	59·0	47·0	4·375	3·590
WS234	2	5	7	44·5	42·4	4·010	3·290
WS235	1	6	7	43·0	47·7	5·390	4·420
WS236	0	4	4	—	59·0	5·910	4·850
WS237	7	12	19	41·0	48·3	13·325	10·925
WS238	—	—	—	—	—	—	—
WS239	—	—	—	—	—	—	—
WS240	—	—	—	—	—	—	—
WS241	—	—	—	—	—	—	—
WS242	—	—	—	—	—	—	—
WS243	—	—	—	—	—	—	—
WS244	9	34	43	41·3	50·0	35·760	29·325
WS245	0	26	26	—	59·8	39·755	32·600
WS246	1	0	1	40·0	—	0·437	0·358
WS248	—	—	—	—	—	—	—
WS250	—	—	—	—	—	—	—

APPENDIX IIc. HAKE DATA: THIRD SURVEY

Numbers of fish in **heavy type**; mean lengths within 10 cm. length groups in *italics*; weights (kg.) in ordinary type. Regions of stations indicated by type as in text.

Station	Hake ♂♂ in 10 cm. length groups 21–30	31–40	41–50	51–60	Hake ♀♀ in 10 cm. length groups 21–30	31–40	41–50	51–60	61–70	71–80	81–90	91–100	101–110	Total males	Total females	Total hake
WS756	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	**No hake**
WS762A	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	**No hake**
WS762B	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	**3 juv.**
WS763	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	**15**
WS764A	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	**3**
WS764B	**7**	**5**	—	—	**5**	**3**	**2**	**3**	**2**	—	—	—	—	**12**	**15**	**27 + 2 juv.**
	28·1	*33·0*	—	—	*26·1*	*36·3*	*47·5*	*53·0*	*67·0*	—	—	—	—	—	—	—
WS765	**1**	**10**	—	—	**2**	**5**	—	**4**	**3**	**1**	—	—	—	**11**	**15**	**26**
	28·0	*32·8*	—	—	*29·0*	*34·8*	—	*56·3*	*65·3*	*76·0*	—	—	—	—	—	—
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	14·500
WS771	**6**	**22**	**13**	—	—	**13**	**31**	**3**	**2**	—	—	—	—	**41**	**49**	**90**
	29·0	*36·0*	*43·7*	—	—	*37·1*	*44·4*	*55·3*	*66·5*	—	—	—	—	—	—	—
	1·250	7·000	7·250	—	—	4·550	21·000	3·350	3·400	—	—	—	—	15·500	32·300	47·800
WS772	—	—	—	—	—	—	**3**	**5**	**1**	—	—	—	—	—	**9**	**9**
	—	—	—	—	—	—	*49·0*	*55·2*	*63·0*	—	—	—	—	—	—	—
	—	—	—	—	—	—	1·700	4·300	1·500	—	—	—	—	—	7·500	7·500
WS773	—	—	**2**	—	—	—	**5**	**26**	**28**	**7**	—	—	—	**2**	**66**	**68**
	—	—	*46·0*	—	—	—	*48·2*	*56·1*	*64·8*	*74·7*	—	—	—	—	—	—
	—	—	1·250	—	—	—	3·900	26·000	48·000	23·500	—	—	—	1·250	101·400	102·650
WS774	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	**No hake**
WS775	**3**	**2**	**2**	—	**10**	**7**	**2**	**7**	**2**	**2***	—	—	—	**7**	**30**	**37**
	26·0	*31·5*	*48·0*	—	*25·0*	*35·1*	*44·0*	*54·7*	*61·0*	*70·5*	—	—	—	—	—	—
	0·350	0·400	? 1·550	—	1·150	2·800	1·000	8·400	2·550	4·400	—	—	—	?	20·300	?
WS776	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	**22 juv.**
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	*19·9*
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1·000
WS777	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	**No hake**
WS781	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	**No hake**
WS782A	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	**No hake**
WS782B	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	**No hake**
WS783	—	—	—	—	—	—	—	**6**	**2**	—	—	—	—	—	**8**	**8**
	—	—	—	—	—	—	—	*56·0*	*65·5*	—	—	—	—	—	*58·4*	—
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	11·000	11·000

* Length groups spaced down 1 cm. in rough log at this station, hence anomalous figure for length of 71–80 cm. group.

Station	Hake ♂♂ in 10 cm. length groups				Hake ♀♀ in 10 cm. length groups									Total males	Total females	Total hake
	21–30	31–40	41–50	51–60	21–30	31–40	41–50	51–60	61–70	71–80	81–90	91–100	101–110			
WS784	— — —	— — —	— — —	— — —	— — —	— — —	**2** *46·0* —	**12** *56·3* —	**2** *63·5* —	— — —	— — —	— — —	— — —	— — —	**16** — 20·000	**16** — 20·000
WS785A	— — —	— — —	— — —	— — —	— — —	— — —	**2** *48·5* —	**5** *53·6* —	**3** *64·7* —	**1** *77·0* —	— — —	— — —	— — —	— — —	**11** — 15·000	**11** — 15·000
WS785B	— — —	— — —	**1** *42·0* —	— — —	— — —	— — —	— — —	**5** *55·2* —	**4** *62·8* —	**2** *72·0* —	— — —	— — —	— — —	**1** — —	**11** — —	**12** — 15·500
WS785C	— — —	— — —	— — —	— — —	— — —	— — —	— — —	**1** *51·0* —	— — —	**1** *74·0* —	— — —	— — —	— — —	— — —	**2** — 4·450	**2** — 4·450
WS786	— — —	— — —	— — —	— — —	— — —	— — —	**3** *48·3* —	**7** *54·4* —	**2** *61·5* —	— — —	— — —	— — —	— — —	— — —	**12** — 14·750	**12** — 14·750
WS787	— —	— —	— —	— —	**1** *30·0*	— —	— —	— —	— —	— —	— —	— —	— —	— —	**1** —	**1** —
WS788	**1** *26·0* —	**2** *39·5* —	**1** *46·0* —	— — —	— — —	— — —	— — —	**1** *51·0* —	— — —	**1** *74·0* —	— — —	— — —	— — —	**4** — 1·450	**2** — 2·690	**6 + 24 juv.** — 5·850
WS789	**3** *24·7* —	**1** *35·0* —	**1** *44·0* —	— — —	— — —	— — —	**1** *50·0* —	**1** *54·0* —	**3** *65·0* —	**1** *71·0* —	— — —	— — —	— — —	**5** — —	**6** — —	**11** — 8·750
WS790A	**14** *27·4* 1·500	**13** *33·8* 3·550	**5** *44·0* 2·900	— — —	**12** *27·1* 1·650	**16** *36·5* 5·400	**34** *46·0* 28·500	**42** *54·6* 48·000	**27** *64·4* 48·100	**3** *73·0* 7·300	— — —	— — —	— — —	**32** — 7·950	**135** — 138·950	**167 + 3 juv.** — 146·980
WS790B	**9** *25·1* 0·900	**12** *33·0* 2·950	**5** *44·2* 2·550	— — —	**14** *24·5* 1·400	**12** *35·6* 3·350	**50** *46·1* 29·500	**59** *55·3* 68·500	**39** *64·4* 65·500	**10** *73·1* 27·500	— — —	— — —	— — —	**26** — 6·400	**184** — 195·750	**210 + 2 juv.** — 202·170
WS791A	**7** *28·1* 1·000	**3** *31·7* 0·700	— — —	— — —	**5** *27·0* 0·650	**4** *34·3* 0·950	**9** *46·7* 5·800	**10** *54·2* 10·100	**4** *63·8* 6·600	— — —	— — —	— — —	— — —	**10** — 1·700	**32** — 24·100	**42** — 25·800
WS791B	**17** *28·0* 2·600	**21** *32·9* 5·200	**4** *42·5* 2·100	**1** *58·0* 1·000	**23** *27·7* 3·500	**32** *33·6* 7·700	**24** *46·8* 17·500	**28** *55·4* 30·000	**9** *64·2* 15·500	**1** *72·0* 2·800	— — —	— — —	— — —	**43** — 10·900	**117** — 77·000	**160** — 87·900
WS792A	— — —	**3** *33·3* 0·950	**1** *43·0* 0·550	— — —	**1** *28·0* 0·200	**1** *33·0* 0·300	**1** *48·0* 0·750	**4** *53·0* 3·950	**1** *61·0* 1·650	**1** *71·0* 2·250	— — —	— — —	— — —	**4** — 1·500	**9** — 9·100	**13** — 10·600

APPENDIX IIc (*cont.*)

Station	Hake ♂♂ in 10 cm. length groups				Hake ♀♀ in 10 cm. length groups									Total males	Total females	Total hake
	21–30	31–40	41–50	51–60	21–30	31–40	41–50	51–60	61–70	71–80	81–90	91–100	101–110			
WS792B	**3** *28·3* 0·500	**5** *34·2* 1·350	**1** ? ?	—	**3** *28·3* 0·450	**3** *35·3* 0·850	**12** *44·6* ?	**27** *55·0* 25·500	**12** *65·3* ?	**8** *74·0* 17·500	—	—	—	**9** — 2·400 + ?	**65** — 71·300?	**74** — 73·700?
WS793	—	—	—	—	—	**1** *36·0* 0·350	**1** *47·0* 0·600	**2** *54·5* 1·800	**1** *62·0* 1·350	**1** *76·0* 2·400	—	—	—	—	**6** — 6·500	**6** — 6·500
WS794	—	—	**2** *43·5* 1·000	—	—	**1** ? 0·475	**23** *47·1* 13·150	**24** *54·7* 24·500	**11** *65·8* 16·500	**1** *72·0* 1·800	—	—	—	**2** — 1·000	**60** — 56·425	**62** — 57·425
WS795	—	—	—	—	—	—	**1** *48·0* 0·700	—	—	—	—	—	—	—	**1** — 0·700	**1** — 0·700
WS796A	**1** *30·0* 0·250	—	—	—	—	**6** *36·5* 2·000	—	—	—	—	—	—	—	**1** — 0·250	**6** — 2·000	**7** — 2·250
WS796B	**1** *28·0* 0·130	—	**2** *45·0* 1·500	—	—	**4** *32·8* ? 0·850	**10** *47·9* 8·100	**24** *55·1* 24·500	**10** *63·7* 14·500	—	—	—	—	**3** — 1·630	**48** — ? 47·950	**51** — ? 49·580
WS797B	**12** *26·8* 1·650	**16** *33·9* 4·400	**6** *43·7* 3·600	—	**6** *23·7* 0·525	**34** *35·4* 10·000	**18** *45·5* 12·000	**12** *55·1* 18·500	**6** *63·2* 9·500	—	—	—	—	**34** — 9·650	**76** — 50·525	**110** — 60·175
WS797C	**6** *26·7* 0·800	**7** *33·4* 1·650	—	—	**8** *26·1* 0·900	**28** *34·5* 7·500	**18** *46·4* 12·000	**28** *55·5* 29·000	**14** *64·0* 21·000	**2** *72·0* 4·900	—	—	—	**13** — 2·450	**98** — 75·300	**111** — 77·750
WS798	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	**No hake**
WS799A	—	—	**3** *43·7* 1·600	—	—	**1** *33·0* 0·225	**10** *47·0* 7·500	**34** *55·1* 35·000	**9** *63·4* 17·000	**1** *73·0* 2·350	**1** *83·0* 2·850	—	—	**3 + ?** — 1·600 + ?	**55** — 64·925	**58 + 13*** — 66·525 + ?
WS799B	—	—	**3** *45·3* 1·800	—	**1** *27·0* 0·125	—	**19** *46·5* 11·500	**52** *55·1* 51·500	**29** *65·4* 44·500	**13** *71·8* 28·500	—	—	—	**3** — 1·800	**114** — 136·125	**117** — 137·925
WS800A	—	—	**1** *47·0* ? 0·800	—	—	—	**3** *49·7* 2·750	**14** *54·9* 17·000	**5** *65·2* 8·500	—	—	—	—	**1** — ? 0·800	**22** — 28·250	**23** — ? 29·050
WS800B	—	—	—	—	—	—	**1** *45·0* 0·600	**9** *57·1* 10·500	**3** *65·2* 6·250	—	—	—	—	—	**13** — 17·350	**13** — 17·350
WS801	—	—	—	—	—	—	**1** *50·0* 0·750	**2** *54·5* 2·050	—	—	—	—	—	—	**3** — 2·800	**3** — 2·800

* 13 males of 19–27 cm. not weighed.

Station	Hake ♂♂ in 10 cm. length groups				Hake ♀♀ in 10 cm. length groups									Total males	Total females	Total hake
	21–30	31–40	41–50	51–60	21–30	31–40	41–50	51–60	61–70	71–80	81–90	91–100	101–110			
WS802A	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	**No hake**
WS802B	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	**No hake**
WS803	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	**No hake**
WS804A	—	—	—	—	—	—	**1** *50·0* 0·800	—	—	—	—	—	—	—	**1** — 0·800	**1** — 0·800
WS804B	—	—	—	—	—	—	**1** *49·0* —	—	**1** *64·0* —	—	—	—	—	—	**2** — 2·400	**2** — 2·400
WS805	—	—	—	—	—	—	**1** *49·0* 0·700	**1** *60·0* 1·400	**1** *65·0* 1·600	—	—	—	—	—	**3** — 3·700	**3** — 3·700
WS806	—	—	—	—	—	—	**2** *47·5* 1·350	**2** *54·5* 2·000	—	—	—	—	—	—	**4** — 3·350	**4** — 3·350
WS807	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	**No hake**
WS808	—	—	—	—	—	—	—	**3** *58·0* 3·850	—	—	—	—	—	—	**3** — 3·850	**3** — 3·850
WS809A	**2** *27·5* 0·350	—	—	—	—	**4** *34·8* 1·250	**1** *47·0* 0·700	**4** *53·0* 3·900	**1** *65·0* 1·600	—	—	—	—	**2** — 0·350	**10** — 7·450	**12** — 7·800
WS809B	—	**3** *32·7* —	**1** *42·0* —	—	**2** *27·0* 0·260	**8** *36·0* 2·750	**12** *46·2* ? 8·010	**24** *55·4* 33·000	**10** *63·5* 18·500	**3** *74·0* 8·500	—	—	—	**4 + 1 juv.** — 1·300	**59** — ? 71·020	**63 + 1 juv.** — ? 72·320
WS810	—	—	—	—	—	**2** *37·0* 0·700	—	—	—	—	—	—	—	—	**2** — 0·700	**2** — 0·700
WS811 I	—	—	—	—	—	—	**1** *48·0* 0·750	**1** *60·0* 1·350	**1** *61·0* 1·550	—	—	—	—	—	**3** — 3·650	**3** — 3·650
WS811 II	—	—	—	—	—	—	—	**15** *58·2* 18·500	**4** *64·0* 8·000	**1** *73·0* 3·200	—	—	—	—	**20** — 29·700	**20** — 29·700
WS812 I	—	**1** *37·0* 0·300	**1** *45·0* 0·700	—	—	**1** *39·0* 0·500	**8** *46·8* 5·700	**18** *55·9* 22·500	**1** *66·0* 2·150	—	—	—	—	**2** — 1·000	**28** — 30·850	**30** — 31·850

APPENDIX IIc (*cont.*)

Station	Hake ♂♂ in 10 cm. length groups				Hake ♀♀ in 10 cm. length groups									Total males	Total females	Total hake
	21–30	31–40	41–50	51–60	21–30	31–40	41–50	51–60	61–70	71–80	81–90	91–100	101–110			
*WS812II**	—	1	3	1	—	5	12	44	29	2	—	—	—	5	92	97
	—	*39·0*	*44·7*	*53·0*	—	*38·2*	*45·9*	*56·3*	*64·1*	*71·0*	—	—	—	—	—	—
*WS813**	—	—	—	—	—	—	—	—	—	1	—	—	—	—	1	1
	—	—	—	—	—	—	—	—	—	*74·0*	—	—	—	—	—	—
WS814	—	—	—	—	—	—	—	1	—	—	—	—	—	—	1	1
	—	—	—	—	—	—	—	*55·0*	—	—	—	—	—	—	—	—
WS815	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	**No hake**
WS816	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	**No hake**
WS817A	—	—	—	—	—	—	—	—	1	—	—	—	—	—	1	1
	—	—	—	—	—	—	—	—	*61·0*	—	—	—	—	—	—	—
	—	—	—	—	—	—	—	—	1·700	—	—	—	—	—	1·700	1·700
WS817B	—	—	—	—	—	—	—	—	—	—	—	1	—	—	1	1
	—	—	—	—	—	—	—	—	—	—	—	*94·0*	—	—	—	—
	—	—	—	—	—	—	—	—	—	—	—	6·100	—	—	6·100	6·100
WS818A	—	—	—	—	—	—	—	—	—	1	1	1	—	—	3	3
	—	—	—	—	—	—	—	—	—	*73·0*	*83·0*	*100·0*	—	—	—	—
	—	—	—	—	—	—	—	—	—	2·500	4·250	7·300	—	—	14·050	14·050
WS818B	—	—	—	—	—	—	—	—	—	1	4	4	1	—	10	10
	—	—	—	—	—	—	—	—	—	*72·0*	*88·0*	*94·8*	*108·0*	—	—	—
WS819A	—	—	—	—	—	—	—	—	—	—	—	1	—	—	1	1
	—	—	—	—	—	—	—	—	—	—	—	*92·0*	—	—	—	—
	—	—	—	—	—	—	—	—	—	—	—	5·000	—	—	5·000	5·000
WS819B	—	—	—	—	—	—	—	—	—	—	1	1	—	—	2	2
	—	—	—	—	—	—	—	—	—	—	*90·0*	*96·0*	—	—	—	—
	—	—	—	—	—	—	—	—	—	—	5·000	7·400	—	—	12·400	12·400
WS820	—	—	—	—	—	—	—	—	—	—	—	1	—	—	1	1
	—	—	—	—	—	—	—	—	—	—	—	*93·0*	—	—	—	—
	—	—	—	—	—	—	—	—	—	—	—	6·650	—	—	6·650	6·650
WS821	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	**No hake**
WS823	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	**No hake**
WS824	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	**No hake**
WS825	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	**No hake**
WS833	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	**No hake**

* Weights unreliable.

Station	Hake ♂♂ in 10 cm. length groups				Hake ♀♀ in 10 cm. length groups									Total males	Total females	Total hake
	21–30	31–40	41–50	51–60	21–30	31–40	41–50	51–60	61–70	71–80	81–90	91–100	101–110			
WS834	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	No hake
WS837	—	—	—	—	—	—	1	—	1	—	—	—	—	—	2	2
	—	—	—	—	—	—	*47·0*	—	*61·0*	—	—	—	—	—	—	—
WS838	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	No hake
WS839	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	No hake
WS840	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	No hake
WS841	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	No hake
WS847 A	—	—	2	—	—	—	2	10	4	1	—	—	—	2	17	19
	—	—	*49·0*	—	—	—	*48·5*	*54·3*	*62·5*	*79·0*	—	—	—	—	—	—
	—	—	1·500	—	—	—	1·350	9·300	6·000	4·050	—	—	—	1·500	20·700	22·200
WS847 B	—	—	—	—	—	—	3	12	6	—	—	—	—	—	21	21
	—	—	—	—	—	—	*47·7*	*55·2*	*65·3*	—	—	—	—	—	—	—
	—	—	—	—	—	—	1·750	12·000	9·000	—	—	—	—	—	22·750	22·750
WS848	—	—	—	—	—	2	1	3	2	1	—	—	—	—	9	9
	—	—	—	—	—	*40·0*	*46·0*	*53·3*	*64·0*	*80·0*	—	—	—	—	—	—
	—	—	—	—	—	1·000	0·650	2·850	3·450	3·100	—	—	—	—	11·050	11·050
WS849	—	—	—	—	—	—	2	6	2	—	—	—	—	—	10	10
	—	—	—	—	—	—	*49·0*	*55·3*	*67·0*	—	—	—	—	—	—	—
	—	—	—	—	—	—	1·500	7·100	3·600	—	—	—	—	—	12·200	12·200
WS850	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	No hake
WS851	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	No hake
WS853	35	307	71	1	14	88	85	18	4	2	—	—	—	414 + 529*	211	1154
	27·7	*36·0*	*42·6*	*51·0*	*26·0*	*36·5*	*44·4*	*54·4*	*64·5*	*74·5*	—	—	—	—	—	—
	4·550	86·000	30·000	0·800	1·750	26·500	42·000	19·000	9·000	5·000	—	—	—	276·350	103·250	379·600
WS855	52	52	26	—	55	20	25	13	7	1	—	—	—	130	121	251
	27·1	*36·0*	*43·0*	—	*27·7*	*34·8*	*44·4*	*55·2*	*65·0*	*73·0*	—	—	—	—	—	—
	6·600	16·500	13·000	—	7·000	7·000	12·500	12·500	12·000	2·200	—	—	—	36·100	53·200	89·300
WS857	3	8	5	—	7	1	2	4	2	—	—	—	—	16	16	32
	28·3	*35·8*	*43·2*	—	*28·6*	*38·0*	*45·0*	*54·3*	*64·5*	—	—	—	—	—	—	—
	0·500	2·100	2·350	—	0·950	0·375	1·000	3·800	3·000	—	—	—	—	4·950	9·125	14·075
WS858	—	13	14	1	—	9	28	13	7	4	—	—	—	28	61	89
	—	*38·0*	*42·7*	*52·0*	—	*38·0*	*45·3*	*55·5*	*62·1*	*73·8*	—	—	—	—	—	—
WS859A	2	70	41	—	5	16	41	15	5	—	—	—	—	113	82	195
	28·5	*36·8*	*43·0*	—	*28·6*	*36·6*	*45·4*	*53·5*	*64·2*	—	—	—	—	—	—	—
	0·260	24·500	16·500	—	0·750	6·250	30·500	16·000	6·000	—	—	—	—	41·260	59·500	100·760
WS859B	4	40	20	—	1	13	17	9	2	—	—	—	—	64	42	106
	28·3	*37·1*	*42·9*	—	*29·0*	*36·6*	*47·4*	*55·1*	*61·5*	—	—	—	—	—	—	—
	0·600	15·500	8·500	—	0·125	4·200	12·000	10·500	2·750	—	—	—	—	24·600	29·575	54·175

* 529 ♂♂ weighed in bulk, not measured.

APPENDIX IIc (*cont.*)

Station	Hake ♂♂ in 10 cm. length groups				Hake ♀♀ in 10 cm. length groups									Total males	Total females	Total hake
	21–30	31–40	41–50	51–60	21–30	31–40	41–50	51–60	61–70	71–80	81–90	91–100	101–110			
WS860	—	4	1	—	—	2	4	6	4	—	—	—	—	5	16	21
	—	*37·8*	*41·0*	—	—	*39·5*	*45·3*	*55·7*	*66·0*	—	—	—	—	—	—	—
	—	1·500	0·480	—	—	0·750	2·500	6·250	7·500	—	—	—	—	1·980	17·000	18·980
WS862	1	6	10	1	2	5	5	3	—	—	—	—	—	18	15	33
	26·0	*37·5*	*43·1*	*55·0*	*27·5*	*36·0*	*48·2*	*56·0*	—	—	—	—	—	—	—	—
	0·100	2·000	4·750	0·900	? 0·250	1·650	3·100	3·050	—	—	—	—	—	7·750	? 8·050	? 15·800
WS864	—	4	4	—	—	—	18	15	4	1	—	—	—	8	38	46
	—	*38·5*	*43·0*	—	—	—	*47·2*	*54·4*	*67·3*	*75·0*	—	—	—	—	—	—
	—	1·100	2·200	—	—	—	12·500	13·000	6·500	2·250	—	—	—	3·300	34·250	37·550
WS866	—	2	5	—	—	—	9	10	7	2	—	—	—	7	28	35
	—	*40·0*	*43·8*	—	—	—	*46·2*	*54·8*	*64·9*	*76·0*	—	—	—	—	—	—
	—	0·750	2·400	—	—	—	5·200	12·000	13·500	5·000	—	—	—	3·150	35·700	38·850
WS868	—	—	2	—	—	—	7	7	1	2	—	—	—	2	17	19
	—	—	*42·0*	—	—	—	*48·0*	*56·6*	*66·0*	*75·0*	—	—	—	—	—	—
	—	—	1·100	—	—	—	5·000	8·250	2·000	4·850	—	—	—	1·100	20·100	21·200
WS870	—	—	—	—	—	—	—	—	1	1	—	—	—	—	2	2
	—	—	—	—	—	—	—	—	*68·0*	*77·0*	—	—	—	—	—	—
	—	—	—	—	—	—	—	—	2·000	3·500	—	—	—	—	5·500	5·500
WS872	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	**No hake**
WS874	—	—	—	—	—	—	—	3	1	1	—	—	—	—	5	5
	—	—	—	—	—	—	—	*53·0*	*62·0*	*74·0*	—	—	—	—	—	—
	—	—	—	—	—	—	—	3·000	1·450	2·600	—	—	—	—	7·050	7·050
WS875	—	—	—	—	—	—	—	2	2	—	—	—	—	—	4	4
	—	—	—	—	—	—	—	*57·5*	*65·5*	—	—	—	—	—	—	—
	—	—	—	—	—	—	—	2·300	3·700	—	—	—	—	—	6·000	6·000

APPENDIX III. APPROXIMATE POSITIONS OF LOCALITIES MENTIONED IN THE TEXT BUT NOT CHARTED

Station: locality	Date	Approximate position	
		Lat. S	Long. W
WS576	17. iv. 31	51° 35′	57° 49·7′
WS582	30. iv. 31	53° 42·5′	70° 55′
WS583	2. v. 31	53° 39′	70° 54·5′
WS586	8. v. 31	48° 27·5′	74° 23·5′
Ringdove Inlet	7. v. 31	49° 48′	74° 18′
Puerto Acero	9. v. 31	47° 40′	74° 45′
Puerto Bueno	6. v. 31	51° 00′	74° 12′
Bahia san Nicholas	2. v. 31	53° 51′	71° 07′
Connor Inlet	11. ix. 31	49° 28′	74° 24′

PLATE XVI

Macruronus magellanicus (× ½). Sketch by Mr E. R. Gunther from a damaged specimen in which the blues were less vivid than in individuals from previous stations. Note that the extension of the fins alters the apparent proportions of the body. (From St. WS99. OTC.)

MACRURONUS MAGELLANICUS

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by

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by

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by

T. John Hart, D.Sc.

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