

SALPS OF THE SOUTHERN OCEAN (AUSTRALIAN SECTOR)
DURING THE 1983-84 SUMMER, WITH SPECIAL
REFERENCE TO THE SPECIES *SALPA*
THOMPSONI, FOXTON 1961

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Abstract: Studies on salps were carried out on the plankton samples collected by R. V. HAKUHO MARU during the KH-83-4 cruise in the Southern Ocean (Australian Sector) as part of the BIOMASS SIBEX I programme.

The geographical distribution of salps showed that widely distributed cosmopolitan species such as *Salpa fusiformis*, *Salpa aspera*, *Thalia democratica* and *Pegea confoederata* reached their southern limit at the Subtropical Convergence. This boundary represents the northern limit for *Salpa thompsoni*, the most abundant salp of the Southern Ocean. *Ihlea racovitzai* was limited to the high latitude Antarctic water.

Analysis of stratified samplings performed day and night revealed a pattern of diel vertical migration for *Salpa thompsoni*, *Salpa fusiformis* and *Ihlea magalhanica*. *Ihlea racovitzai* did not show a clear vertical movement between the day time and the night time. The vertical distribution of *Ihlea magalhanica* and *Ihlea racovitzai* appeared to extend deeper than the range determined previously.

A pattern of vertical stratification in the size composition and stages of maturity for both aggregate and solitary forms of *Salpa thompsoni* was observed. Moreover, a comparison of the population at different latitudes revealed different compositions.

1. Introduction

One of the most important ecological features of the zooplankton in the Southern Ocean is their response to the strong seasonal increase of phytoplankton production which occurs in a very short period of time (NEMOTO and HARRISON, 1981). The salps show several ways of adaptation to this kind of environment. Among them, a rapid and exponential increase in population size to take immediate advantage of increased food supply is the most outstanding (ALLDREDGE and MADIN, 1982). Thus, the salps appear to be an excellent example of colonizing species (HERON, 1972a, b; SILVER, 1975).

In the Southern Ocean the study of salps is of special interest because they occur in high concentrations or swarms, and being primarily herbivorous they must play an important role in utilizing the phytoplankton production.

From 1961 Foxton began to publish a series of important works (FOXTON, 1961, 1966, 1971) concerning the taxonomy and ecology of salps in this area, based on the data of the Discovery Investigation samples. He clarified the taxonomical status of *Salpa thompsoni*, *S. gerlachei*, *Ihlea magalhanica* and *I. racovitzai*, as well as the distri-

bution and abundance patterns of these four species confined to the Southern Ocean. Several aspects of the life history of *S. thompsoni* were well studied in FOXTON (1966) with observations on a related species *S. gelachei*.

CALDWELL (1966) and ESNAL (1970) also considered ecological and taxonomical aspects of the salps of the Southern Ocean. They showed some discrepancies in the distributional ranges previously determined by FOXTON (1966) for *S. thompsoni* and *S. gelachei*.

In this paper we describe the general features of the distribution and abundance of salps in the Southern Ocean (Australian Sector). On the basis of stratified samples we discuss some aspects of the vertical distribution and diel vertical migration patterns. Special reference has been made to the population ecology of *Salpa thompsoni*, due to its importance as the most abundant salp and one of the most common zooplankters in the Southern Ocean.

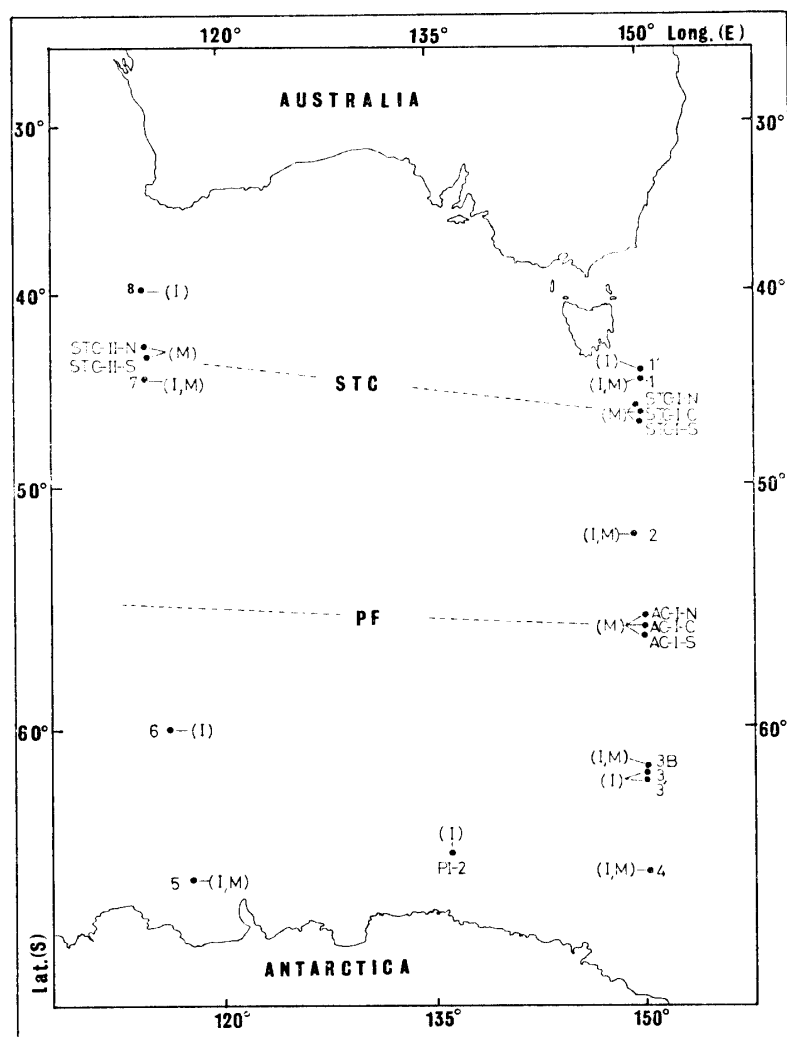


Fig. 1. Study area and the position of stations where 10-foot IKMT net (I) and MTD net (M) collections were performed. STC: Subtropical Convergence, PF: Polar Front.

2. Material and Methods

This study was carried out on the basis of plankton samples collected by R. V. HAKUHO MARU during the KH-83-4 cruise in the Southern Ocean (Australian Sector) as part of the BIOMASS SIBEX I programme (Fig. 1). Plankton collections were made by a 10-foot IKMT net (5 mm mesh size) with oblique hauls from the surface to a depth of 1000 m, and by a Motoda horizontal net (MTD net, 0.1 mm and 0.33 mm mesh size) which was towed horizontally mostly in 10–20 different strata between 1000 m and the surface (Table 1). The MTD samples were collected in the day-and-night series. To determine the towing depth and the volume of water filtered, a depth-distance recorder and a flowmeter were set at the mouth of the net. In oblique tow the net was lowered and recovered at a speed of about 1 m/s while the ship cruised at a constant speed of 2 kn. In horizontal tow the net was lowered to the requisite depth while the ship was sailing at a speed of 2 kn.

The specimens were preserved in 5% neutral sea water formalin solution. The number of solitary and aggregate forms of each species in each sample was counted. In the case of large samples containing more than 1000 specimens, subsampling was necessary. The abundance of salps was expressed in the number of individuals per 1000 m³ of water filtered.

The standard body length of each species in both the solitary and the aggregate forms was measured. This standard measurement is defined as the distance between the mouth and the atrial opening as shown in Fig. 2. The body size data were divided into 5 mm size groups.

In the case of *Salpa thompsoni* the composition of the population at different stations and at different depths was studied. For this purpose arbitrary stages of maturity for the solitary and the aggregate forms were registered based on the previous descrip-

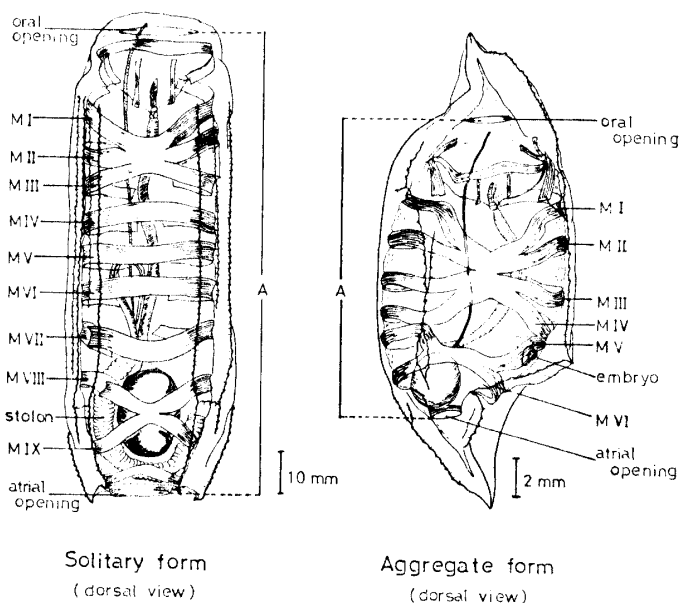


Fig. 2. Schematic dorsal view of the solitary and aggregate forms of *Salpa thompsoni* to show the standard body length measurement (A). M: I–IX indicate nine body muscles respectively.

Table 1. List of sampling data during KH-83-4 cruise.

Stn.	Location (S) (E)		Date	Time	Net type	Mesh size (mm)	Sampling layer (m)
1	45°06.8'	150°09.9'	1983 Dec. 14	0925-1345	10 ft-1KMT	5.0	0-1050
2	52 07.4	149 52.6		16 1301-1506	"	"	0-905
3	61 27.0	150 29.6		19 1522-1752	"	"	0-870
4	64 56.4	150 10.4		21 1051-1325	"	"	0-670
3B	61 25.6	150 00.1		26 0018-0304	"	"	0-860
1'	44 58.7	150 00.4	1984 Jan. 9	0100-0140	"	"	0-97
3'	61 32.3	150 26.3		13 1615-1818	"	"	0-535
PI-2	64 13.5	135 43.1		17 0032-0232	"	"	0-570
5	65 01.6	118 12.2		19 0343-0548	"	"	0-780
6	60 00.3	116 01.0		22 0130-0410	"	"	0-862
7	44 48.4	114 57.3		27 0045-0310	"	"	0-980
8	39 57.7	114 51.5		28 1714-1932	"	"	0-863
1	44 59.8	150 04.4	1983 Dec. 14	0040-0305	MTD	0.10	0, 11, 34, 57, 85, 114, 170, 227, 300, 400, 500, 599, 799, 999
2	52 09.0	149 41.6		16 0041-0101	"	"	0, 11, 32, 54, 81, 108, 161, 215
4	64 41.1	150 40.5		23 1419-1602	"	"	0, 11, 33, 55, 83, 110, 165, 220, 316, 421, 526, 632, 842, 1052
4	64 54.3	150 21.8		23 0235-0506	"	"	0, 11, 32, 53, 79, 105, 158, 210, 324, 432, 540, 648, 864, 1080
3B	61 17.5	150 02.2		26 1233-1430	"	"	0, 11, 33, 55, 83, 110, 165, 220, 291, 388, 485, 581, 775, 969
AC-I-N	55 59.1	150 08.5		28 0150-0205	"	0.33	0, 11, 33, 55, 82, 109, 164, 218
AC-I-C	56 12.2	150 00.5		28 0542-0557	"	"	0, 11, 34, 56, 84, 112, 168, 224
AC-I-S	56 23.2	149 59.5		28 2159-2214	"	"	0, 10, 31, 52, 78, 104, 155, 207
STC-I-N	46 28.3	149 59.7		31 1445-1501	"	"	0, 11, 32, 54, 80, 107, 161, 214
STC-I-C	46 45.7	150 02.5		31 2156-2210	"	"	0, 10, 32, 51, 77, 103, 154, 205
STC-I-S	47 00.4	150 00.4	1984 Jan. 1	0625-0640	"	"	0, 11, 34, 56, 84, 113, 169, 225
5	65 03.8	117 54.1		19 1625-1837	"	"	0, 11, 33, 56, 84, 112, 167, 223, 318, 424, 530, 636, 848, 1060
5	66 00.0	118 00.9		19 0045-0240	"	"	0, 11, 33, 54, 80, 107, 161, 214, 285, 380, 475, 570, 760, 950
7	44 50.8	114 56.0		26 1410-1647	"	"	0, 12, 36, 61, 91, 122, 182, 243, 317, 422, 528, 633, 844, 1055

Table 1. Continued.

Stn.	Location (S) (E)		Date	Time	Net type	Mesh size (mm)	Sampling layer (m)
7	45°01.0'	115°00.0'	1984 Jan. 26	0050-0233	MTD	0.33	0, 11, 32, 53, 80, 106, 159, 212, 291, 388, 485, 582, 776, 970
STC-II-S	43 24.0	114 54.7	27	2210-2230	"	"	0, 15, 43, 73, 109, 145, 218, 291
STC-II-N	43 00.3	114 51.7	28	0131-0151	"	"	0, 11, 34, 57, 85, 114, 171, 228

tion by FOXTON (1966).

Aqueous staining by Toluidine Blue and Rose Bengal was employed for revealing details of the test and muscle bands.

3. General Life Cycle of Salps

The distribution patterns of salps depend strongly on some aspects of their life cycle. A brief description of *Salpa thompsoni* is given here based on FOXTON (1966) (see Fig. 3). The cycle includes two generations: sexually reproducing generation (the aggregate form) and asexually reproducing generation (the solitary form), distinctly differing in morphology.

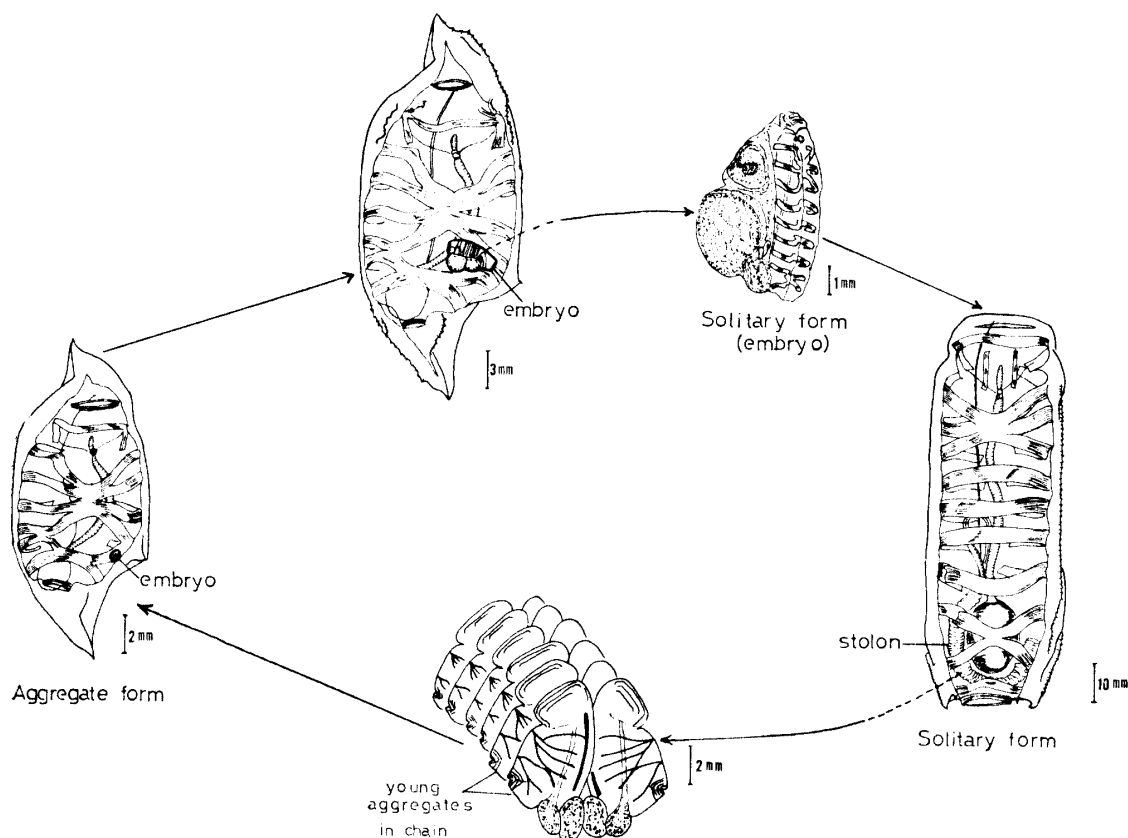


Fig. 3. General life cycle of *Salpa thompsoni*.

The aggregate form produces one embryo which develops inside the parent's body. The embryo is released as a solitary form. This oozoid grows to maturity. In the mature solitary form a stolon is the organ of reproduction. This stolon grows by budding a chain of aggregates. In detail, a stolon is composed of successive blocks of two rows of young aggregates. Within a given block the aggregates are in the same stage of maturity. After complete development a block of aggregates is released and the young aggregates begin the cycle again.

4. Results and Discussion

4.1. Horizontal distribution and abundance

The horizontal distribution and abundance of all species found in the study area are shown in Fig. 4.

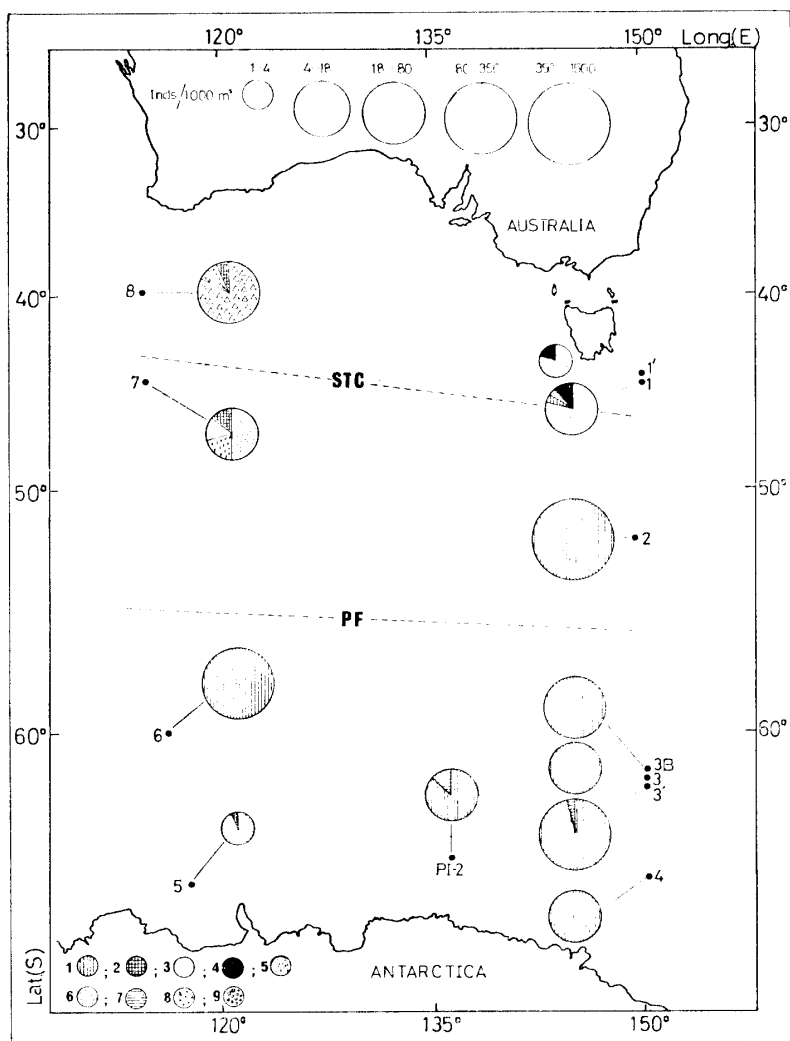


Fig. 4. Horizontal distribution and abundance of salps collected by 10-foot IKMT net. STC: Subtropical Convergence, PF: Polar Front. 1. *Salpa thompsoni*, 2. *S. fusiformis*, 3. *S. aspera*, 4. *Thetys vagina*, 5. *Thalia democratica*, 6. *Iasis zonaria*, 7. *Ihleia racovitzai*, 8. *I. magalhanica*, 9. *Pegea confoederata*.

The three water masses under consideration showed a different composition of species:

Subtropical water: characterized by the presence of widely distributed cosmopolitan species such as *Iasis zonaria*, *Thetys vagina*, *Salpa aspera*, *Salpa fusiformis*, *Thalia democratica* and *Pegea confoederata*.

Subantarctic water: dominated by *S. thompsoni*, the most common salp of the Southern Ocean.

Antarctic water: only two species, *S. thompsoni* and *Ihlea racovitzai*, were present in this area.

Salpa thompsoni occurred in Subantarctic and Antarctic waters. The maximum abundance was recorded from Stn. 2. The Subtropical Convergence appears to be the northern limit of its distribution. However, we found specimens of both aggregate and solitary forms at Stn. 1 situated north of the Subtropical Convergence. Stratified samples collected by the MTD net at the same station revealed that *S. thompsoni* was present at a depth of 300 m. FOXTON (1966) suggested that the exceptional occurrences of *S. thompsoni* north of the Subtropical Convergence are due to intrusions of the Subantarctic water penetrating below the Subtropical water.

The species of the Genus *Ihlea* found in the study area, *Ihlea magalhanica* and *I. racovitzai*, showed discontinuous latitudinal ranges: *I. magalhanica* was recorded at Stns. 8 and 7 located north and south of the Subtropical Convergence respectively. On the other hand, *I. racovitzai* was restricted to the southern Antarctic water with a maximum abundance at Stn. 5. The distribution area of *I. magalhanica* was reported within northern Subantarctic and southern Subtropical waters (FOXTON, 1971), its distribution not restricted by the Subtropical Convergence. The same author defined *I. racovitzai* as a truly Antarctic species with a northern boundary lying some distance south of the Polar Front.

If we look at the southern Antarctic area where *S. thompsoni* and *I. racovitzai* occur, we can see a pattern of their distribution: the point of maximum abundance for each species did not overlap; *I. racovitzai* reached its maximum at Stn. 5, while *S. thompsoni* showed its peak in the eastern part of this region at Stn. 3'. This feature probably suggests the existence of competitive pressures between the two species, resulting in a mutual restriction within middle and high latitudes of the Antarctic water. Further, it is necessary to consider other physical and biological factors that determine the geographical distribution ranges for the two species. If we compare the geographical distribution of salps with that of euphausiids collected during the same cruise (TERAZAKI and WADA, 1986) a similarity between *I. racovitzai* and *Euphausia superba* can be observed.

In the Subtropical region, *Thalia democratica* is the most abundant salp. It has been reported by several authors (THOMPSON, 1948; HERON, 1972a) that this species occurs commonly in very dense swarms. *Iasis zonaria* was the second in abundance here. At Stn. 7 this species was very abundant too. The Subtropical Convergence is not a barrier for its distribution. CALDWELL (1966) reported occurrence of this species from as far as 55°S, and ESNAL *et al.* (1983) found specimens of *I. zonaria* at 53°S. *Salpa fusiformis* and *S. aspera* reach the southern limit of their distribution at the Subtropical Convergence (FOXTON, 1961). In our collection we found these two species at Stn.

7 located south of the mean position of the Subtropical Convergence. Nevertheless, the hydrographic observations carried out in this area revealed that the Subtropical Convergence was not clearly defined. It was considered to be located at 43–44°S which coincided with a weak surface front (NAKAI *et al.*, 1985).

In summary, the region of Subtropical Convergence represents a faunistic boundary at which widely distributed species reach their southern limit. For *S. thompsoni* it is the northern limit of its range. Distribution of *I. zonaria* and *I. magalhanica* is not restricted by the Subtropical Convergence region.

In the meantime, *S. thompsoni* is dominant at middle latitudes of the Southern Ocean, whereas *I. recovitzai* is restricted to the high latitudes of the Antarctic water.

4.2. Vertical distribution and migration

The vertical distribution and migration are still a debated subject in the Salpidae. As they feed primarily on phytoplankton, salps has been regarded as near surface living animals restricted to the euphotic zone. However, there are reports on the occurrence of salps at great depths (FOXTON, 1966; CALDWELL, 1966). MACKINTOSH (1934), HARDY and GUNTHER (1935) and FOXTON (1966) reported that *S. thompsoni* undergoes diel vertical migration. The same observation was made for *S. fusiformis* (FRANQUEVILLE, 1971) and *S. aspera* (WIEBE *et al.*, 1979).

Although our data are not enough to attempt any generalization, they can add new evidences to clarify this aspect of the ecology of salps, especially in the Southern Ocean.

The most abundant salp, *S. thompsoni*, has been collected at several stations by the MTD net, giving us an opportunity to observe its vertical distribution in a transect along 150°E (Fig. 5).

At Stn. 4, the day-and-night collections from the surface to the 1000 m depth were performed. During the night *S. thompsoni* was concentrated at depths between 0 and 75 m. In the daytime it was found between 200 and 300 m. Thus a clear vertical movement between the daytime and the nighttime can be seen. Other samples collected at midnight at Stns. AC-I-N and 2 also showed the species in the shallow water. In contrast, at Stn. 3B where the sampling was performed at noon, *S. thompsoni* was found below 50 m in depth with a maximum abundance at a 300 m depth. We can infer that distributions at Stns. AC-I-C (0542–0557 h) and AC-I-S (2159–2214 h) show transitional patterns between the day and the night.

The vertical distribution of *S. fusiformis* is shown in Fig. 6. The day-and-night series were performed at Stn. 7. During the night the bulk of the population was concentrated between 0 and 75 m depths, but low concentrations were found during the daytime. Stn. STC-II-N sampled at midnight shows again this species is distributed in the shallow water. Stn. STC-II-S shows the situation at nightfall (see Table 1). The swimming speed of *S. fusiformis* has been estimated from a laboratory study to be of about 1.2–3.0 m/min (MACKIE and BONE, 1977). As the feeding, locomotion and respiration in salps are accomplished in the same process, they appear to swim actively all day. With such a swimming speed of *S. fusiformis* we can suppose a diurnal vertical movement of about 1500 to 2000 m. Moreover, *S. fusiformis* has been reported to be not affected by the temperature changes in the water column along its vertical migra-

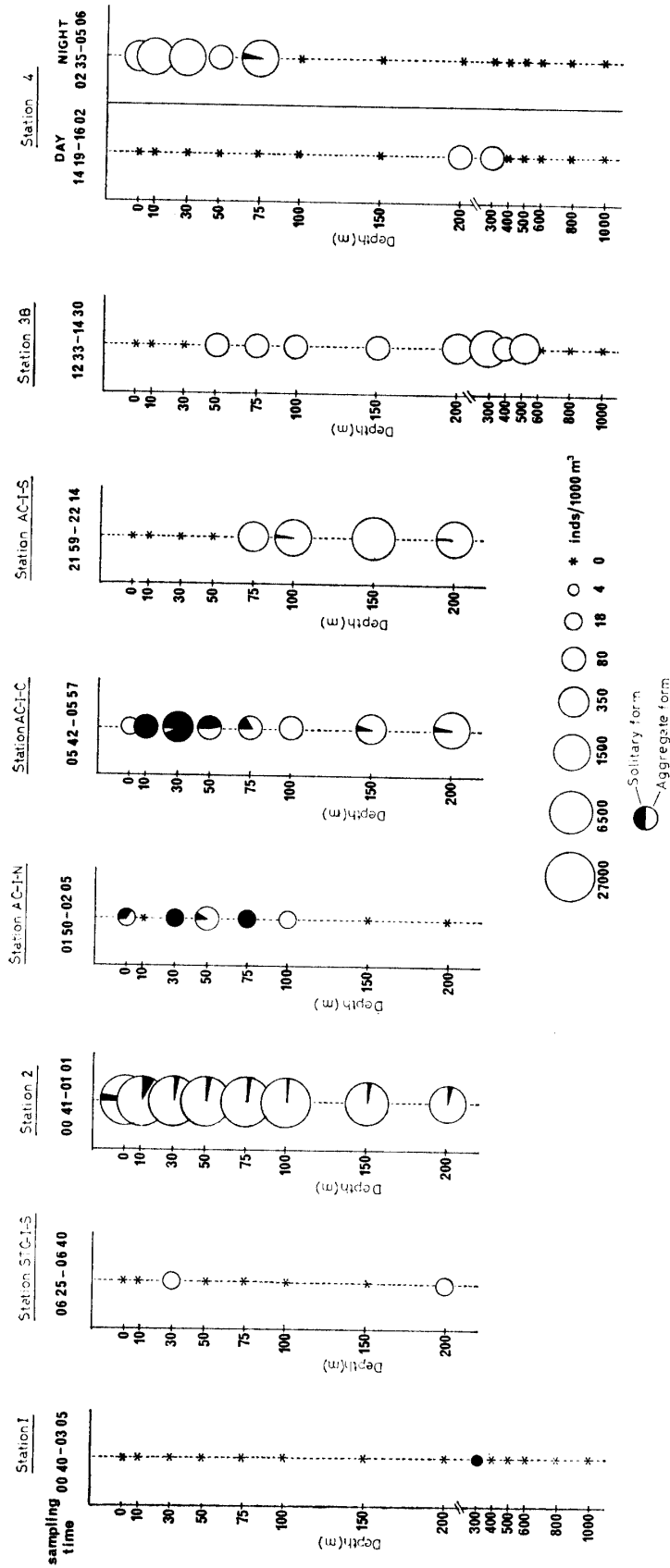


Fig. 5. Vertical distribution and abundance of *Salpa thompsoni*.

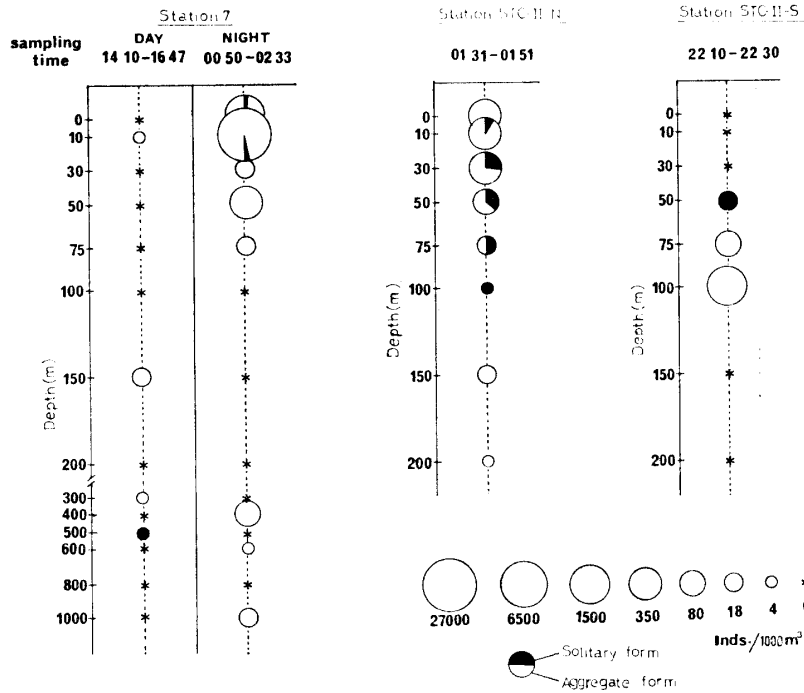


Fig. 6. Vertical distribution and abundance of *Salpa fusiformis*.

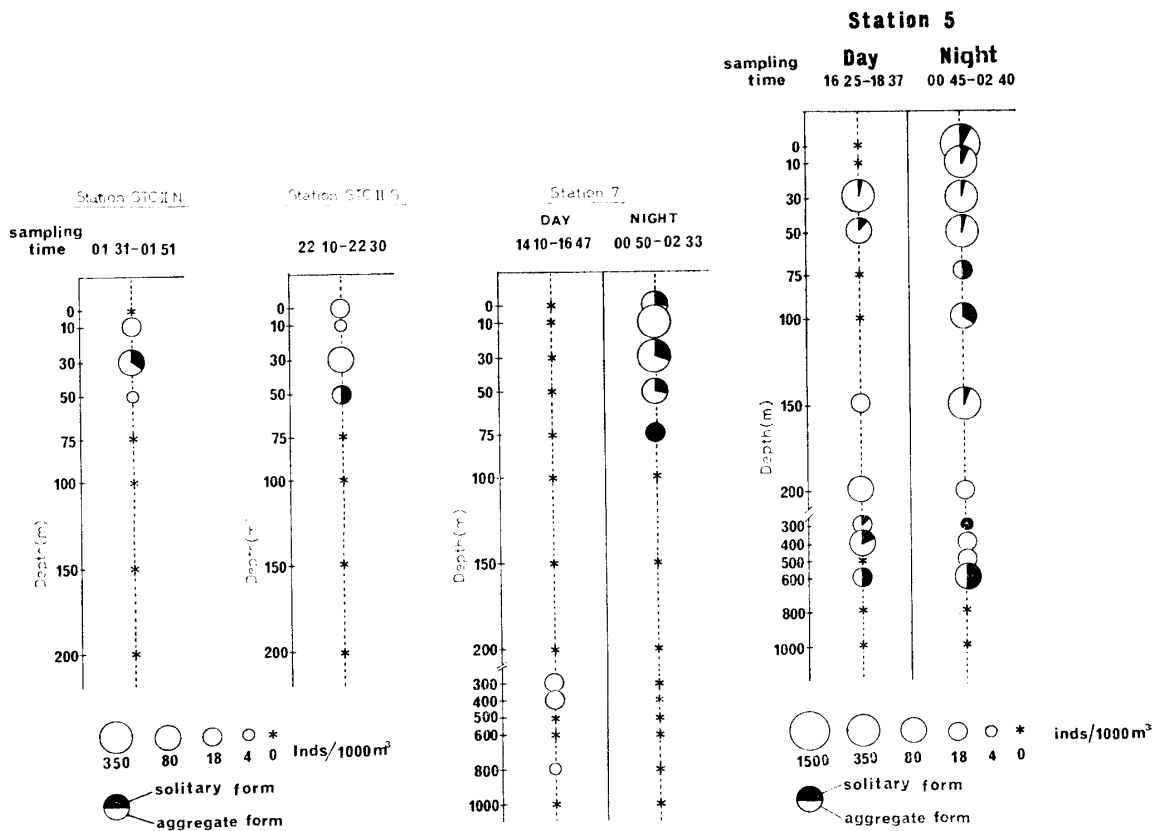


Fig. 7. Vertical distribution and abundance of *Ihlea magalhanica*.

Fig. 8. Vertical distribution and abundance of *Ihlea racovitzai*.

tion (HARBISON and CAMPENOT, 1979). All these features and the present sampling data support the assumption that *S. fusiformis* migrates vertically.

The vertical distribution of *Ihlea magalhanica* and *I. racovitzai* has been reported to occur within the upper 100 m or the euphotic zone (THOMPSON, 1948; FOXTON, 1971). FOXTON (1971) stated that the examination of samples from the depths deeper than 100 m failed to reveal the presence of either species. Our data suggest the existence of the two species at greater depths. For *I. magalhanica* (Fig. 7) the day-and-night series at Stn. 7 showed a possible pattern of diel vertical migration from the surface layer at night to a deeper layer below 300 m in the daytime. Stn. STC-II-N and STC-II-S sampled at night showed the species in the surface layer. In the case of *I. racovitzai* (Fig. 8) the day-and-night series at Stn. 5 showed a more or less uniform vertical distribution down to a 600 m depth. Vertical displacement between the day and the night is not so evident, though in the daytime *I. racovitzai* was absent at 0 and 10 m depths.

The analysis of stratified sampling data confirms the pattern of diel vertical migration for *S. thompsoni* and *S. fusiformis*. As for *I. magalhanica* and *I. racovitzai*, it is important to remark on the finding of these two species at a deeper layer than that mentioned in the previous reports. Moreover, a possible pattern of diel vertical migration was observed in *I. magalhanica*.

4.3. Vertical stratification of the size composition

Based on the stratified MTD net samples, vertical differences in the size composition of the two forms of *S. thompsoni* and *I. racovitzai* were observed. The abundance of these two species at Stns. 2 and AC-I-C (*S. thompsoni*) and Stn. 5 (*I. racovitzai*) allowed us to establish a good comparison of the size composition among different depths.

The mean body length of aggregate and solitary forms of *S. thompsoni* with depth at Stns. 2 and AC-I-C is shown in Fig. 9. The same result is shown in Fig. 10 for *I. racovitzai* at Stn. 5; in this case the day-and-night series were considered. A common pattern is observed for the two species: small-sized aggregates and large-sized solitaries predominate in the surface layer, while large-sized aggregates and small-sized solitaries constitute the deeper layer population.

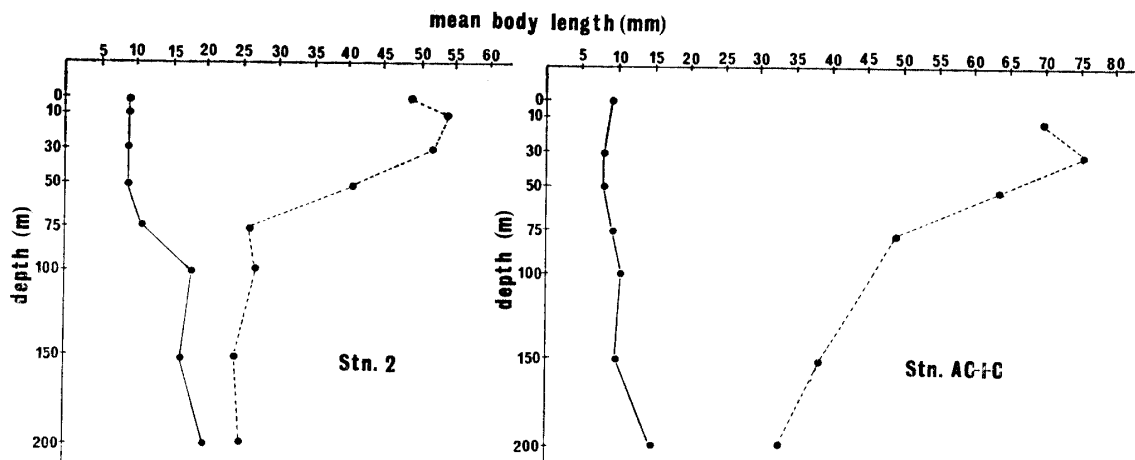


Fig. 9. Mean body length of solitary and aggregate forms of *Salpa thompsoni* with depth at Stns. 2 and AC-I-C. Solid line, aggregate form; broken line, solitary form.

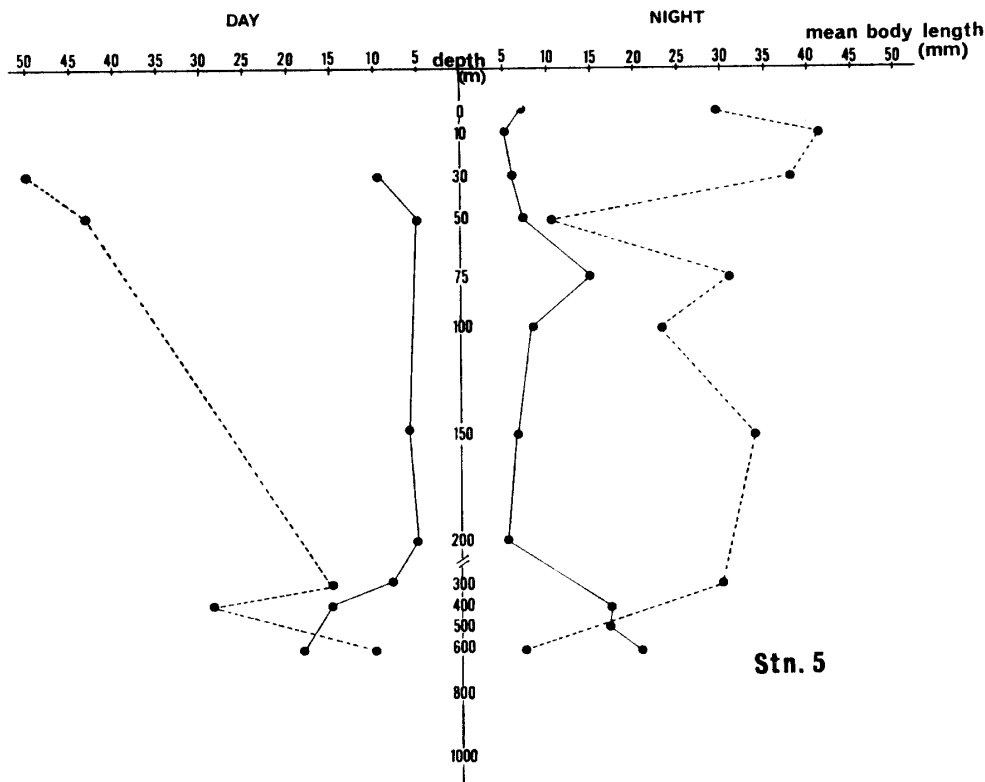


Fig. 10. Mean body length of solitary and aggregate forms of *Ihlea racovitzai* with depth at Stn. 5. Day-and-night series were considered. Solid line, aggregate form; broken line, solitary form.

In the case of *S. thompsoni* the body size and its growth are related to the stage of maturity: an increase of the body size of the solitary form represents an increase of the stolon size and its capacity for budding. In the case of the aggregate form the relation is not so close, but in general mature embryos tend to occur in larger aggregates. Therefore, the vertical stratification of the size composition will be reflected in the composition of maturity stages at different depths. This feature will be discussed in the next section.

In the case of *I. racovitzai*, we were not able to study the stages of maturity; the fragility of the salps of the Genus *Ihlea* do not permit a detailed examination of the reproductive organs (the stolon of the mature solitary is frequently broken and detached from the body), so several aspects of the sexual and asexual reproduction could not be considered.

4.4. Composition of developmental stages in the *Salpa thompsoni* population

The developmental stages for both aggregate and solitary forms of *S. thompsoni* were defined by FOXTON (1966). Due to the complexity of these stages we will give here a brief description by means of schematic representations (Figs. 11 and 12) to show some important morphological characters.

The developmental stages determined for the solitary form (Fig. 11) are based on the growth of the stolon and the release of successive blocks of buds. Stages 0, 1,

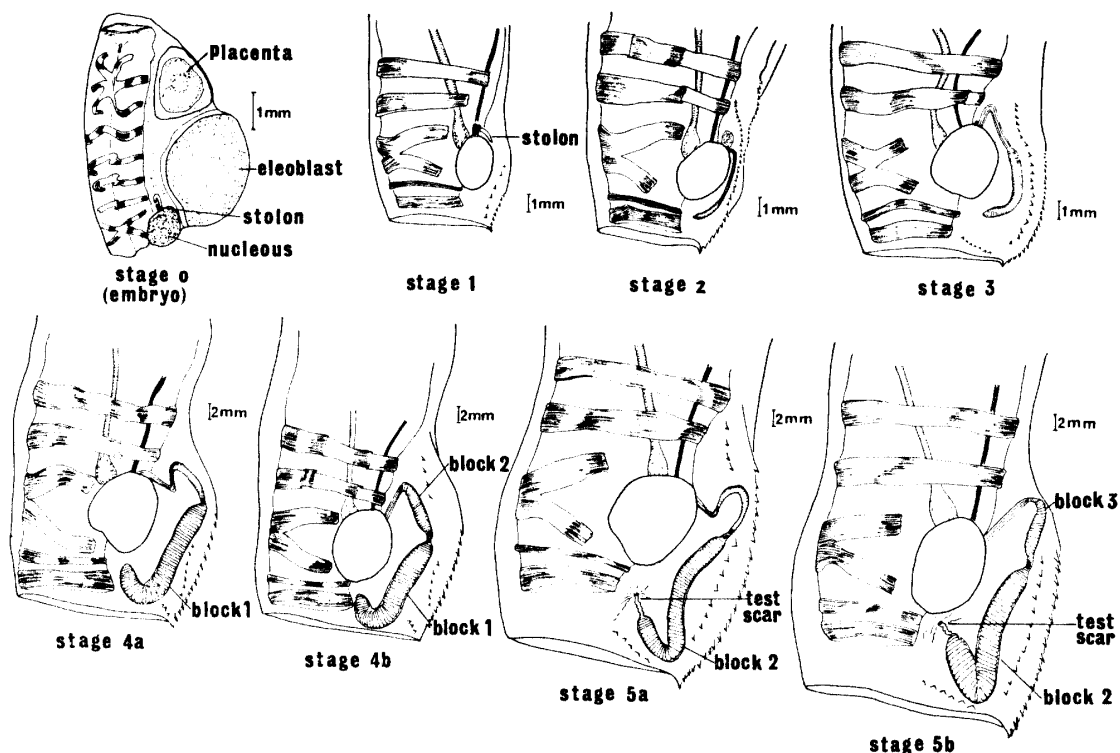


Fig. 11. Schematic representation of the developmental stages for the solitary form of *Salpa thompsoni*. Lateral view of the solitary embryo (stage 0); stages 1 to 5b, detail of posterior part to show the growth of the stolon.

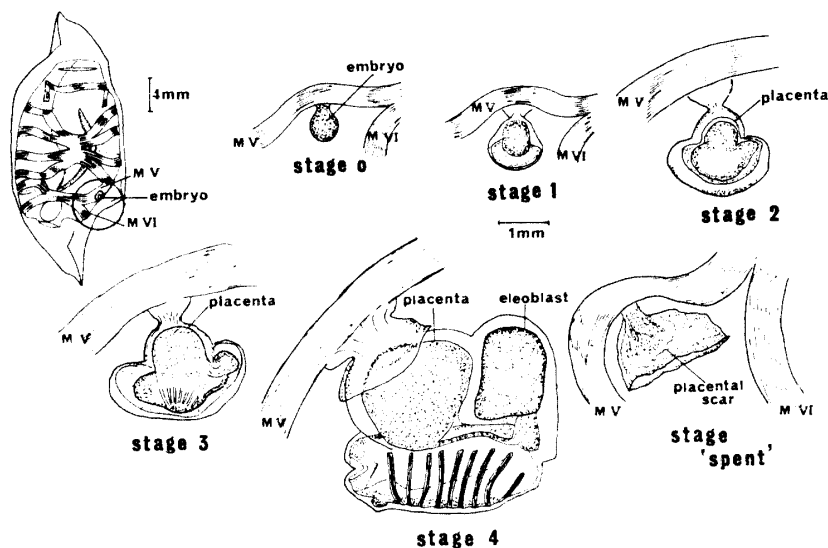


Fig. 12. Schematic representation of the developmental stages for the aggregate form of *Salpa thompsoni* (stages 0 to "spent") based on the growth of the embryo inside the aggregate.

2, 3 and 4a represent the development of the solitary form from a newly released embryo to the stage when the first block (block 1) is fully differentiated. Stage 4b is characterized by the presence of a second block (block 2). At stage 5a the first block has been

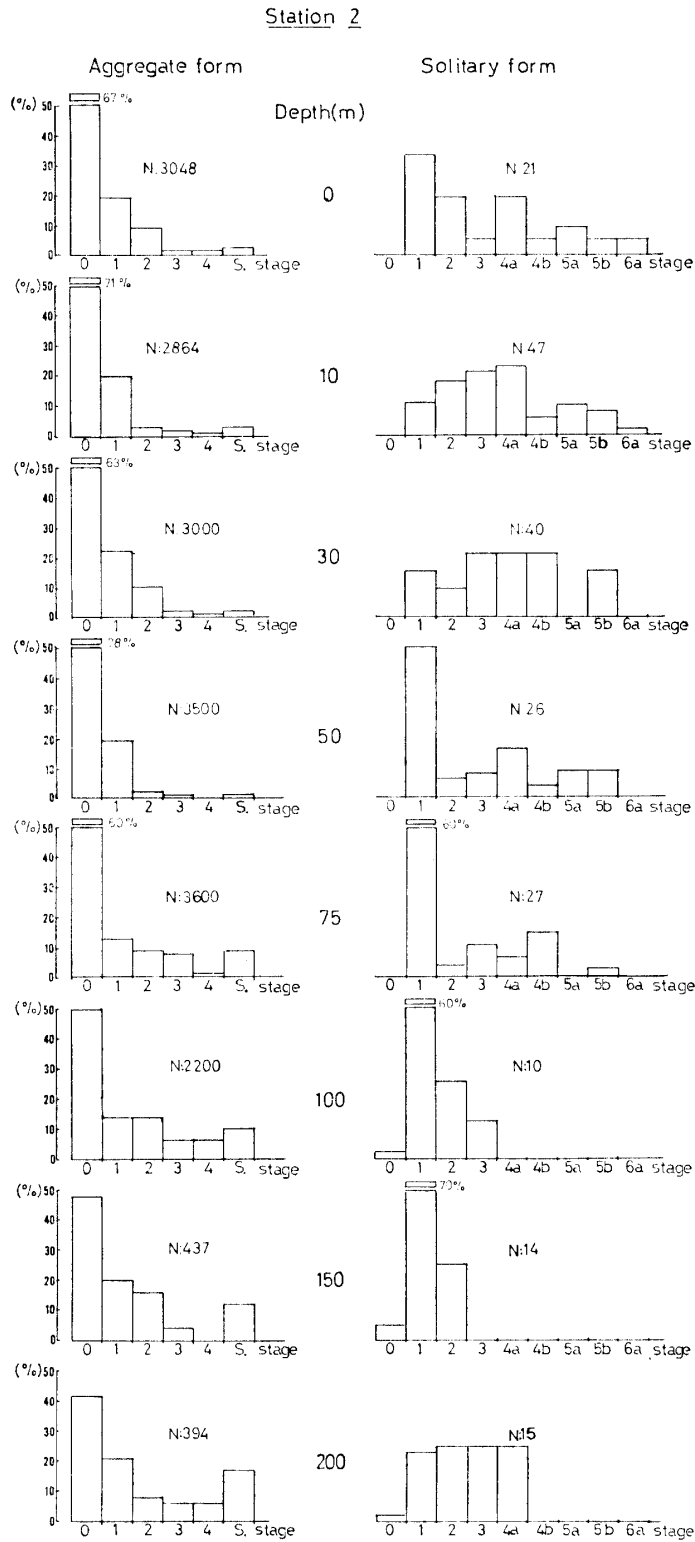


Fig. 13. Distribution of the developmental stages with depth in percentage for the aggregate and solitary forms of *S. thompsoni* at Stn. 2. S, spent; N, number of specimens.

released through a hole in the test, and the second block of stage 4b is now distal on the stolon (the presence of a scar in the test is an important character to distinguish stage 5a from 4a). Stage 5b has two blocks and the distal one (block 2) is about to be released. Subsequent to stage 5 it is possible to define in the same way stages 6 and 7 although the solitaries that survive to such stages are rare.

For the aggregate form the developmental stages were defined on the basis of the growth of the embryo inside the aggregate and the presence of a placental scar as evidence of its having been released. The aspect of the embryo at successive stages of maturity (stages 0 to 4) and the placental scar until the embryo is released (stage "spent") are shown in Fig. 12.

a) Vertical distribution of the developmental stages

Figure 13 shows the percentage composition of the developmental stages with depth for the aggregate and the solitary forms of *S. thompsoni* at Stn. 2. For the solitary form in the surface layer, all stages are present and there is no predominant group. At a 50m depth an increase of stage 1 occurs. At 100, 150 and 200 m depths only immature stages are present. For the aggregate form in the surface layer a predominance of young stages is observed. At a 75m depth an increase of mature stages (stage 4 and "spent") occurs. In the deeper layer the percentage of "spent" stage increases, although the percentage of young immature individuals is high.

In the shallow water the presence of solitaries at stages 4, 5 and 6 reveals a process of active budding which is in agreement with the high proportion of young aggregates at stage 0 of maturity. On the other hand, in the deeper layer the increase of "spent" aggregates and the predominance of immature solitaries suggest that these young solitaries have been released from their parents.

The vertical distribution of the mean body length for both solitary and aggregate forms is in agreement with the vertical distribution of developmental stages corresponding to large sizes for mature individuals and small sizes for immature ones. Thus a pattern of vertical stratification can be seen: while the budding activity takes place in the shallow layer, the production of young solitaries (spawning) predominates in the deeper layer. In all cases the activity in the solitary population can be correlated with that of the aggregate population. The same pattern can be seen at Stn. AC-I-C as shown in Fig. 14.

FOXTON (1966) was able to follow seasonal changes in the occurrence of the developmental stages for the two forms. He states that during March and April, the solitary population in the shallower as well as the deeper layer is composed of immature individuals at stages 0 or 1. By August the shallower population reaches maturity and stages 4a and 4b become predominant. In the meantime the deeper population develops at a slower rate and by August they are still at stage 1 of maturity. During spring and summer the deeper solitary population rises to a shallower depth to grow and augment the actively budding surface population. As a result of this budding activity, large quantities of small immature aggregates are released, but as they grow and their embryo develops, they tend to sink into the deeper water where spawning occurs. As the season progresses the budding activity decreases and the production of young solitaries in the deeper layer predominates. Thus the deeper population of young solitaries perpetuates the stock throughout the winter. Although we were not able to study seasonal changes

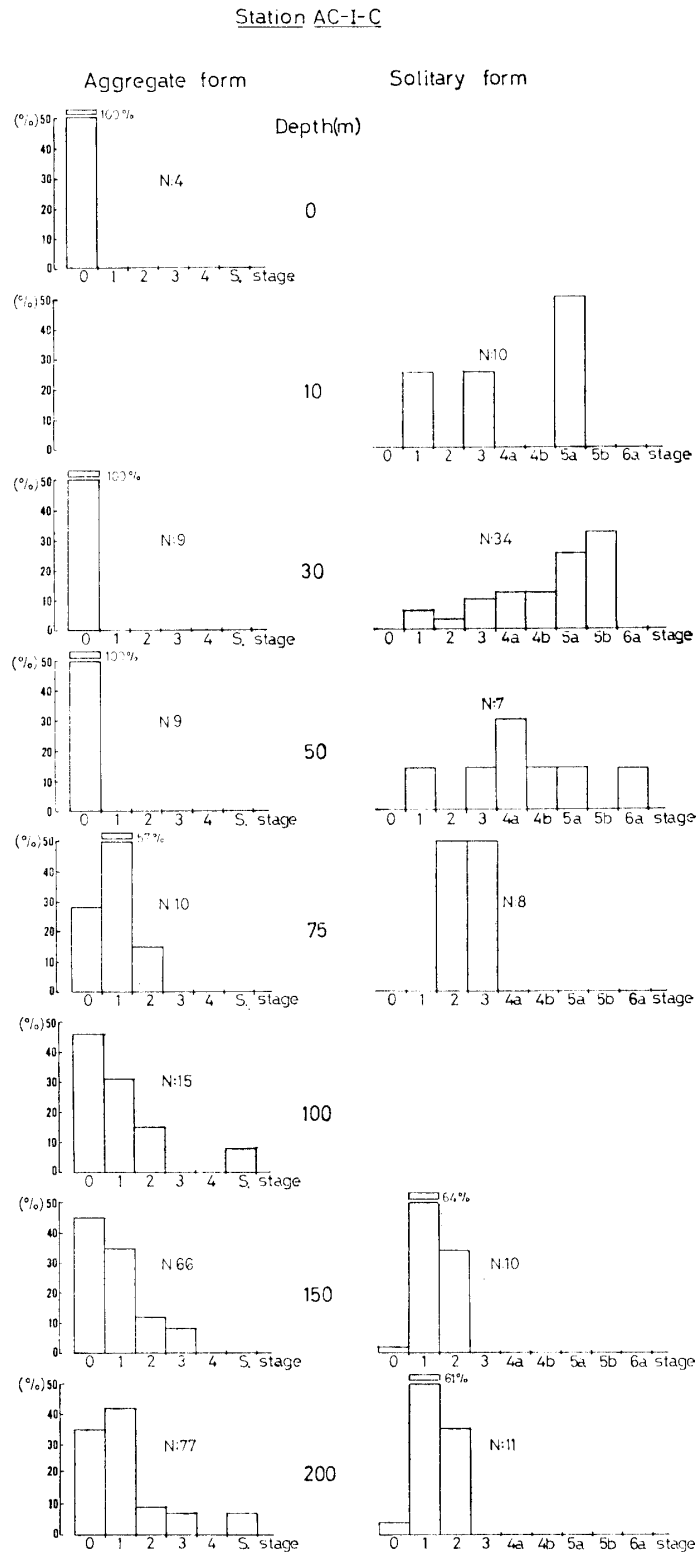


Fig. 14. Distribution of the developmental stages with depth in percentage for the aggregate and solitary forms of *S. thompsoni* at Stn. AC-1-C. *S.*, spent; *N*, number of specimens.

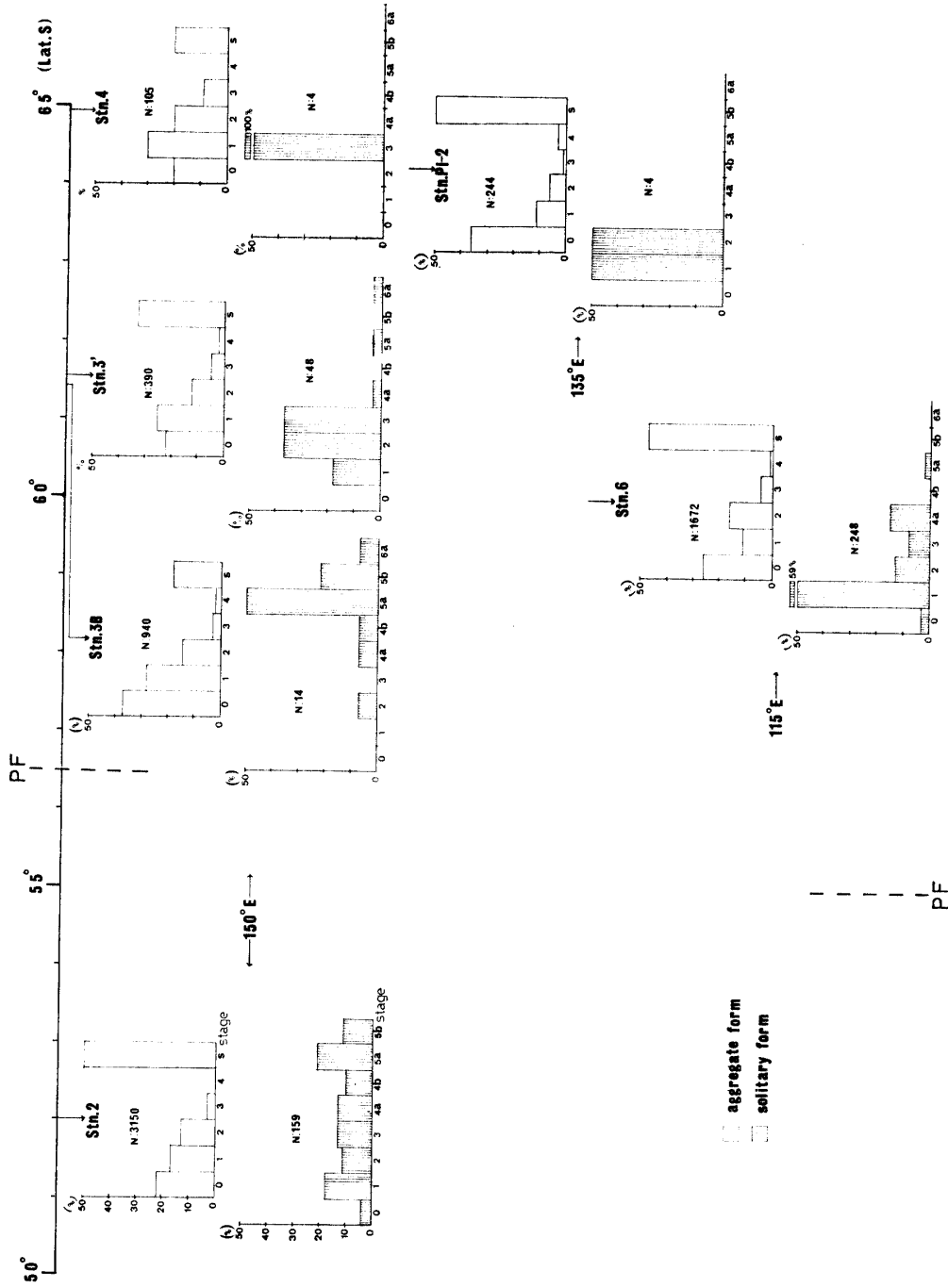


Fig. 15. Percentage composition of the developmental stages for the aggregate and solitary forms of *S. thompsoni* at different latitudes. S, spent; N, number of specimens.

in the composition of the population, our samples confirm the pattern of vertical stratification in the developmental stages for the summer population. These data together with the observations made by FOXTON (1966) for the winter population, suggest the existence of seasonal-ontogenetic vertical migration pattern for the solitary population.

b) Latitudinal variation in the composition of developmental stages

By the comparison of the composition of the population of *S. thompsoni* at several latitudes it is suggested that growth of the population varies from north to south.

Figure 15 represents the percentage composition of developmental stages for the solitary and aggregate forms of *S. thompsoni* at different latitudes. Stns. 2, 3B and 4 were sampled during December; Stn. 3', 6 and PI-2 during January. At Stn. 2 in the Subantarctic water the population of the solitary form was mixed. The presence of stages 4 and 5 reveals that active budding is taking place; this is confirmed in the aggregate population by the presence of young individuals at stages 0 and 1 of maturity. On the other hand, the presence of solitaries at stages 0, 1, 2 and 3 together with mature aggregates at "spent" stage of maturity suggests that embryos have been released. Stn. 3B in the Antarctic water also shows a population in the process of active budding with a predominance of solitaries at stage 5 of maturity in correlation with the predominance of young recently released aggregates at stages 0 and 1. At Stn. 4 the situation is quite different with a solitary population represented by immature individuals at stage 3 of maturity; no predominant group exists in the aggregate population.

In the January data, Stns. 6 and 3' show a solitary population with a predominance of young individuals in relation to a high proportion of mature aggregates at "spent" stage of maturity; solitaries at stages 4, 5 and 6 are present in a low proportion revealing that budding is not the predominant activity. The population at Stn. PI-2 is comparable to that at Stn. 4 due to the presence of only immature solitaries at stages 1 and 2.

At Stn. 2 the population is in a period of maximum activity producing large quantities of young aggregates and increasing the solitary population with the production of young embryos. Budding activity is also predominant at Stn. 3B. The population at Stn. 4 is characterized by a low level of production; the absence of mature solitaries suggests that budding activity does not occur there.

The January samples at Stns. 6 and 3' show a decrease in the budding activity and an increase in the production of young solitaries. At Stn. PI-2 as well as Stn. 4 the population without budding activity falls to a low level of abundance.

In conclusion, the budding activity of the December samples decreases from north to south; the Subantarctic population is in maximum of production, while the high latitude Antarctic population is falling to minimum where budding activity does not occur.

If we compare Stn. 3B (December) with Stns. 6 and 3' (January), the budding activity observed at Stn. 3B is replaced by the spawning activity or the production of new embryos.

It is difficult to explain the falling of budding capacity at Stns. 4 and PI-2. Probably the summer swarming activity attains several peaks separated by the periods when the budding activity ceases and the solitary population is replaced by young individuals.

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