STUDIES ON THE DISTRIBUTION OF APPENDICULARIANS AND SOME THALIACEANS OF THE NORTH PACIFIC, WITH SOME MORPHOLOGICAL NOTES[1]

TAKASI TOKIOKA

Seto Marine Biological Laboratory, Sirahama

With 16 Text-figures and 36 Tables

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INTRODUCTION

From the standpoint of the distribution of chaetognaths of the North Pacific, I proposed the possibility of separating the *bedoti*-water as a distinct water mass from the vast far oceanic *pacifica*-dominant water mass (1959). Besides, I tried to distinguish the *enflata*-dominant equatorial water mass in the same paper. However, in order to ascertain these ideas, it is very necessary to find out some plankton animals other than chaetognaths, which are distributed in similar manners as in the above-mentioned chaetognaths. For this reason, I am going to analyse the distribution of appendicularians of the North Pacific in the same way as that adopted in my former study of chaetognaths in 1959. Namely, predominant species are selected out at first, ratios among these species are calculated and then the distribution of ratio values is studied. In the warm water of the North Pacific, *Oikopleura longicauda* and *O. fusiformis* can be taken up as predominant forms as seen clearly in Table 1 showing the abundance of respective

species in the collections treated in the present paper. Thus, the ratio F/L (= *O. fusiformis/O. longicauda*) was calculated about each available sample. By the way, distributions of *Doliolum denticulatum, Doliolum nationalis* and *Dolioletta gegenbauri* var. *tritonis* in the North Pacific are studied in this paper in relation to various water masses. Further, a notice was paid on the distribution of *Thalia democratica* var. *orientalis* to find out whether or not the distribution of this variety and that of the typical form are segregative.

Although I used many data published by various authors together with my own unpublished ones to build up the general outline of the distribution of appendicularians and some thaliaceans of the North Pacific, most parts of the data were obtained while I was staying at the Scripps Institution of Oceanography in 1956–57 to study a part of the vast collection of plankton samples kept there. Consequently, this paper might be regarded as the third paper dealing with the results of my appendicularian studies made at that laboratory. All of my own unpublished data, mentioned above, are shown in appended tables at the end of this article. Because there have not yet been any papers in which the distribution of appendicularians is discussed in the scale of the North Pacific, this paper might be regarded as a preliminary report on this subject, although there remain still some wide areas, where the appendicularian fauna has never been studied. Besides the distributional studies, some short morphological notes on several species will be found in later pages.

Before going further, I want to express my hearty thanks to the staff of the Scripps Institution of Oceanography for granting me the favour of a seat at the laboratory for a year, especially to Prof. M. W. JOHNSON for his kindness in providing facilities and also to the Rockefeller Foundation for a postdoctoral fellowship.

MATERIAL AND METHODS

The material treated in this article comprises all of the seven collections mentioned in my previous paper (1959) on the North Pacific chaetognaths and a few other collections which are described fully in respective chapters where the data on these collections are published for the first time. Here, I have to express my hearty thanks again to Prof. FRED B PHLEGER and members of the Foraminifera Laboratory of the Scripps Institution of Oceanography for their kindness in allowing me to examine the plankton samples collected from Scammon's and Manuela lagoons and to quote some of the hydrographical data in this paper, as those samples included a number of *Oikopleura dioica* and thus they offered very important data for the distribution of this species.

The whole contents were examined with a magnification of 30× or under the microscope with more higher magnifications, when the samples collected with small nets were treated. Every individual of each species was identified carefully

and counted. However, only a quater of the contents was examined in this way, when the large net samples were dealt with.

It is clear that the present material is not satisfactory as to the evenness of the distribution of sampling stations and times in respective areas referred to. Moreover, there is another difficulty which cannot be overcome easily. As the body consistency of appendicularians is not so tough and ready to be easily mutilated, lots of specimens are often found damaged and cannot be identified. The proportion of these damaged specimens to the whole appendicularian population is usually much larger in respective samples than in the cases concerning chaetognaths. If the damaged specimens occurred in a certain proportion to the whole population in respective species, then the existence of such unidentified specimens would not be a significant obstacle in discussing the quantitative distribution of respective species. Actually, however, some species can be identified very exactly even in a heavily damaged condition, these include *Fritillaria pellucida, F. formica* and sometimes some oikopleurids belonging to the subgenus *Vexillaria* having a tough tail-musculature with subchordal cells; while some other oikopleurids belonging to the subgenus *Coecaria* having a rather delicate tail-musculature without any subchordal cells and such fritillarians as *F. haplostoma* can hardly be identified with certainty in a damaged state. It is very probable that latter forms are damaged more easily than former ones. Thus, the distribution of damaged and unidentified individuals among species cannot be parallel to that of identified individuals. And yet, this discrepancy can never be adjusted in any way. For these reasons, the acuracy of the ratio F/L, percentages of respective species and other values estimated on these should be lowered for some extent. It seems quite impossible to assess the extent, some people might consider it is scarcely possible to deduce any trends from the arrangement of such values, but I believe the trends found in the distribution of those values are reliable when abundant data are treated. To do with many data seems to be the only solution for the above-mentioned difficulty. In computing percentages, ratios and means, fractions less than 1/2 were disregarded and the rest were counted as units.

APPENDICULARIANS OCCURRED IN THE WHOLE COLLECTIONS TREATED IN THIS PAPER

Forty forms of appendicularians were identified in the present material. They are:

1. *Oikopleura* (*Coecaria*) *longicauda* (VOGT), 1854
2. *Oikopleura* (*Coecaria*) *intermedia* LOHMANN, 1896
3. *Oikopleura* (*Coecaria*) *fusiformis* FOL, 1872
4. *Oikopleura* (*Coecaria*) *fusiformis* f. *cornutogastra* (AIDA), 1907

5. *Oikopleura* (*Coecaria*) *gracilis* LOHMANN, 1896
6. *Oikopleura* (*Coecaria*) *graciloides* LOHMANN & BÜCKMANN, 1924
7. *Oikopleura* (*Vexillaria*) *dioia* FOL, 1872
8. *Oikopleura* (*Vexillaria*) *rufescens* FOL, 1872
9. *Oikopleura* (*Vexillaria*) *parva* LOHMANN, 1896
10. *Oikopleura* (*Vexillaria*) *cophocerca* GEGENBAUR, 1855
11. *Oikopleura* (*Vexillaria*) *albicans* (LEUCKART), 1854
12. *Oikopleura* (*Vexillaria*) *labradoriensis* LOHMANN, 1892
13. *Megalocercus huxleyi* (RITTER), 1905
14. *Megalocercus abyssorum* CHUN, 1888
15. *Stegosoma magnum* (LANGERHANS), 1880
16. *Folia gracilis* LOHMANN, 1892
17. *Pelagopleura verticalis* (LOHMANN), 1914
18. *Althoffia tumida* LOHMANN, 1896
19. *Sinisteroffia scrippsi* TOKIOKA, 1957
20. *Bathochordaeus* sp.
21. *Fritillaria* (*Acrocercus*) *haplostoma* FOL, 1872
22. *Fritillaria* (*Acrocercus*) *abjornseni* LOHMANN, 1909
23. *Fritillaria* (*Acrocercus*) *arafoera* TOKIOKA, 1956
24. *Fritillaria* (*Acrocercus*) *aberrans* LOHMANN, 1896
25. *Fritillaria* (*Acrocercus*) *formica* f. *digitata* LOHMANN & BÜCKMANN, 1926
26. *Fritillaria* (*Acrocercus*) *fraudax* LOHMANN, 1896
27. *Fritillaria* (*Acrocercus*) *gracilis* LOHMANN, 1896
28. *Fritillaria* (*Acrocercus*) *charybdae* LOHMANN, 1899
29. *Fritillaria* (? *Acrocercus*) *pacifica* TOKIOKA, 1958
30. *Fritillaria* (*Eurycercus*) *pellucida* (BUSCH), 1851
31. *Fritillaria* (*Eurycercus*) *borealis* f. *typica* (LOHMANN), 1900
32. *Fritillaria* (*Eurycercus*) *borealis* f. *intermedia* (LOHMANN), 1905
33. *Fritillaria* (*Eurycercus*) *borealis* f. *sargassi* (LOHMANN), 1896
34. *Fritillaria* (*Eurycercus*) *megachile* FOL, 1872
35. *Fritillaria* (*Eurycercus*) *tenella* LOHMANN, 1896
36. *Fritillaria* (*Eurycercus*) *venusta* LOHMANN, 1896
37. *Tectillaria fertilis* (LOHMANN), 1896
38. *Tectillaria taeniogona* (TOKIOKA), 1957
39. *Appendicularia sicula* FOL, 1874
40. *Kowalevskaia tenuis* FOL, 1872

All the specimens of *Fritillaria* (*Acrocercus*) *formica* FOL, 1872 were represented by forma *digitata* LOHMANN & BÜCKMANN in the present material. The abundance of respective species in each collection is shown in the Table 1, besides Tables 3, 4, 7–11, 13–22 are needed for making the general outline of the appendicularian distribution in the North Pacific. The following eight species

O. longicauda
O. fusiformis
O. rufescens
Frit. borealis f. *sargassi*
Frit. pellucida
Steg. magnum
O. cophocerca
M. huxleyi

are considered to be common ones throughout the eight collections from the warm water regions of the Indo-Pacific, especially first three are outstanding. It is very clear that *O. longicauda* is the commonest species and *O. fusiformis* may be said as following it. Thus, the ratio between these two species (F/L) was calculated as to respective samples and the distribution of this ratio was studied.

OCCURRENCE OF APPENDICULARIANS AND SOME OTHER PELAGIC TUNICATES IN RESPECTIVE COLLECTIONS

I. APPENDICULARIANS FOUND IN THE SAMPLES COLLECTED IN THE SUBARCTIC WATERS

(Appendix Table 1)

Only two species, *O. labradoriensis* and *Frit. borealis* f. *typica*, occurred in 34 samples collected in the subarctic waters during the Transpac-Expedition; the former was much more abundant than the latter. *O. labradoriensis* was very abundant at Stations TP 25 and TP 37 and pretty dense at Stations TP 30 and TP 44, while *Frit. borealis* f. *typica* was fairly abundant at Station TP 42. This seems to strengthen the possibility that *O. chamissonis* MERTENS 1831, an insufficiently described form from the Bering Straits might be identical with *O. labradoriensis*.

II. APPENDICULARIANS IN THE MIXING AREA BETWEEN THE SUBARCTIC WATER AND THE WARM WATER

(Table 2)

In the Transpac-Expedition samples from the mixing area between the subarctic and the warm water, *O. longicauda* was much more abundant then *O. fusiformis* which occurred only rarely. The component of the appendicularian population in each sample including *O. labradoriensis* is shown below in Table 2. This shows evidently that *O. longicauda* is predominant among warm water species in both eastern and western mixing areas. The collection made by the Japanese survey ship and presented to the Transpac Expedition party contains only a single sample in which *O. labradoriensis* is found; forty *O. longicauda* and a

Collections	JS	TP	SB	MP	EQP	CP	AR	CI	Total
O. longicauda	**6900**	**3828**	**3400**	**1809**	**2200**	**1312**	**4560**	**4400**	**28409**
O. intermedia	—	6	96	33	40	42	32	72	321
O. fusiformis	**962**	**2080**	474	486	**700**	**2492**	319	**1134**	**8647**
O. fusiformis f. *cornutogastra*	16	*	10	9	*	—	**836**	8	*879
O. gracilis	—	16	8	—	—	—	—	64	88
O. graciloides	32	120	51	9	40	—	—	12	264
O. dioica	63	240	19	12	—	—	432	105	871
O. rufescens	371	**528**	**511**	**689**	**700**	**671**	**1300**	**803**	**5573**
O. parva	—	24	42	7	—	7	2	115	197
O. cophocerca	10	174	**553**	**588**	160	36	160	464	**2145**
O. albicans	—	120	264	77	20	—	—	135	616
O. labradoriensis	25	372	—	—	—	—	—	—	397
M. huxleyi	—	16	126	200	160	**1204**	27	36	**1769**
M. abyssorum	—	—	*	18	—	—	—	—	*18
Steg. magnum	78	145	174	192	180	**810**	9	**620**	**2208**
Folia gracilis	—	—	*	—	—	—	—	—	*
P. verticalis	—	—	42	—	?*	?4	—	45	*91
Alth. tumida	—	1	39	2	?*	25	—	—	*67
Sin. scrippsi	—	—	8	—	—	—	—	—	8
Bathochordaeus sp.	—	—	*	—	*	—	—	—	*
Frit. haplostoma	28	80	31	32	40	44	80	112	441
Frit. abjornseni	—	2	—	—	—	—	10	—	12
Frit. arafoera	5	—	—	—	—	—	2	—	7
Frit. aberrans	—	4	29	28	*	—	—	—	*61
Frit. formica f. *digitata*	224	81	52	63	80	172	25	108	805
Frit. fraudax	5	—	*	24	40	—	—	8	*77
Frit. gracilis	—	—	*	*	40	—	—	28	*68
Frit. charybdae	—	—	*	—	—	—	—	—	*
Frit. pacifica	—	1	15	—	80	—	—	—	96
Frit. pellucida	26	154	150	100	**1840**	256	8	114	**2648**
Frit. borealis f. *typica*	10	252	—	—	—	—	—	—	262
Frit. borealis f. *intermedia*	—	—	4	—	*	—	—	12	*16
Frit. borealis f. *sargassi*	**638**	**610**	99	490	320	126	**1120**	462	**3865**
Frit. megachile	10	16	*	6	40	35	—	16	*123
Frit. tenella	—	—	54	49	**640**	—	—	—	743
Frit. venusta	—	—	44	6	160	22	—	—	232
T. fertilis	63	34	15	*	20	—	2	—	*134
T. taeniogona	—	—	15	—	—	—	—	—	15
App. sicula	96	63	*	*	—	—	464	45	*668
K. tenuis	*	*	*	—	—	143	2	—	*145
Oikopleurids damaged	444	1008	3700	3690	2600	2500	384	1022	15348
Fritillarians damaged	33	54	40	84	80	21	4	108	424
Number of samples	19	97	48	56	5	28	55	26	334

Table 1. The value *Frequency of Occurrence*×*Mean Percentage* of each species in respective collections made in the warm water regions of the Indo-Pacific.

AR—The collection from the Arafura Sea, CI···The central part of the tropical Indian Ocean, CP···The Central Pacific surveyed by the Syunkotu-Maru, EQP···The collection of the Equapac Expedition, JS···The collection made by the Japanese Survey Ship in the offshore waters off the north-eastern part of Honsyû Island, Japan; MP···The collection of the Midpac Expedition, SB···The Shellback Expedition, TP···The Transpac Expedition. *···The value less than 1, in the last column it indicates that the numerals show the total of values excluding those less than 1.

single damaged and unidentified specimen were found in this sample (see J3 of Appendix Table 18). In many samples collected by the vertical haul from 50–100 m to the surface in the Japan Sea, were found considerable numbers of *O. labradoriensis*, too. In these samples, besides *O. labradoriensis*, *O. longicauda* and *O. dioica* were found most frequently as seen later in Tables 16–18 in the

Stations	TP 18	TP 26	TP 33	TP 51	TP 52	TP 57A	TP 58A	TP 61	TP 67	TP 68	TP 73	11 samples
O. labradoriensis	4	2	5	25	14	13	5	5	5	1	2	F.O.–100%
O. longicauda		1	1	12	11	21	4	10	38	28	36	91
O. fusiformis					10		10					18
O. dioica											21	9
Oikopleurids damaged				2	2	1	1				3	45
Frit. pellucida	18				1							18
Frit. borealis f. *typica*				14	3	2	576					36

Table 2. Occurrence of appendicularians in the Transpac-Expedition samples collected in the mixing area between the subarctic water and the warm water.

chapter concerning the appendicularian fauna of the Japan Sea. In southern part of this sea, however, the distribution of *O. labradoriensis* seemed frequently to be segregated vertically from those of *O. longicauda* and other warm water forms, namely the former was found confined to the submerged cold water mass, while the latter were abundant in the surface warm water.

III. PELAGIC TUNICATES IN THE BLUE-GREEN WATER ALONG THE SOUTHERN CALIFORNIAN COAST

(App. Tables 2 and 3, Table 3 and Text-fig. 1)

Eight species of appendicularians occurred in the nineteen plankton samples collected March 12–13, 1956 in the coastal blue-green water along the Californian coast from San Diego to Long Beach, when a small net, 17 cm in the mouth diameter, was towed from 20–40 m to the surface. *O. dioica* occupied the largest part of the appendicularian population and *Frit. borealis* f. *typica* did also a significant part. Small numbers of *O. longicauda* were found in samples collected near the boundary between the blue-green water and the more offshore blue water. The occurrence of a few *O. labradoriensis* together with a considerable number of *Frit. borealis* f. *typica* shows evidently that the water of the surveyed area was influenced by the subarctic water carried by the California Current at that time and the predominance of *O. dioica* indicates that the neritic nature was highly retained there at the same time (App. Table 2).

The 35 plankton samples collected off San Diego with a similar small net and stored at the Scripps Institution contained a large number of *O. longicauda* and a pretty amount of *O. dioica* (App. Table 3). Here occurred a significant number of *O. fusiformis*, although F/L being only 0.03. A few *Frit. borealis* f. *sargassi* together with f. *typica* were found in this collection. Thus, it is clear that the water of the surveyed area was the mixture of the neritic water and the warm oceanic water and partly affected by the subarctic influx. Of Thaliacea, *Doliolum nationalis* and *Dolioletta gegenbauri* var. *tritonis* were found in this collection. Although RITTER (1905) reported *Doliolum tritonis*, *Doliolum ehrenbergii* and *Doliolum mülleri* from the San Diego region, it is hardly possible to determine which of *D. denticulatum* or *D. nationalis* is represented by his *D. ehrenbergii*.

	off San Diego (35 samples)	Blue-grean water (19 samples)
O. longicauda	4095	63
O. fusiformis	136	*
O. dioica	1880	8400
O. parva	—	*
O. labradoriensis	—	*
Frit. abjornseni	12	—
Frit. pellucida	—	*
Frit. borealis f. *typica*	17	1500
Frit. borealis f. *sargassi*	28	—
App. sicula	9	—
K. tenuis	—	*

Table 3. Abundance of respective species of appendicularians in the coastal waters of southern California.
Numerals indicate values *Frequency of occurrence*×*Mean percentage*, *—less than 1.

Frit. borealis f. *typica* occurred also at Stations 1 and 3 of the Transpac Expedition, which were situated near the blue-green water; there occurred, at the same time, a few individuals of *O. cophocerca*, a warm oceanic water form.

The outline of the appendicularian fauna of this area is shown clearly by ESSENBERG's works (1922 and 1926) based on daily collections taken from the surface of the water at or near the end of the pier at the Scripps Institution for Biological Research for three years. According to her papers, maximum numbers of appendicularian individuals were to be found in the winter season, from October to March or April; minimum numbers in summer. "In general the data shows a very marked correlation between the temperature of the water

and the number of appendicularians, in which increase of temperature is accompanied by or followed by decrease in numbers and vice versa". *O. dioica* and *O. longicauda* were the commonest species, they occurred even throughout summer and rarely in large numbers in this warm season. Other forms occurred mostly in winter and unevenly in the season, unusually dense populations of *O. fusiformis* and *Frit. formica* were recorded. In all, she listed forty-eight species, of which thirty were new species. I believe, however, this number is too large for this region. In my opinion, her list is reducible to the following twenty-one forms, all her new species being treated as synonyms of already known species.

1. *O. longicauda*
2. *O. fusiformis*
3. *O. graciloides* (=*O. californica* ESSENBERG)
4. *O. dioica*
5. *O. rufescens*
6. *O. cophocerca*
7. *O. labradoriensis*

It is very possible that *O. albicans* described by ESSENBERG may be identical with *O. labradoriensis*, because the shape of its left stomach lobe and the arrangement of the subchordal cells resemble those of *labradoriensis* rather than those of *albicans*.

8. *Oikopleura vanhöffeni* LOHMANN, 1896
9. *Steg. magnum*

Megalocercus diegensis ESSENBERG may be safely identified as *Steg. magnum*, as IHLE has already mentioned in his note of 1929.

10. *Pelagopleura gracilis* LOHMANN, 1914 (=*Althoffia pacifica* ESSENBERG)
11. *Frit. haplostoma*

Frit. lucibila and *Frit. limpida* described by ESSENBERG as new species are evidently identical with the present species. *Frit. truncata* ESSENBERG might also be treated under this species.

12. *Frit. abjornseni*

Frit. lohmanni, *Frit. amygdala* and *Frit. tereta* described by ESSENBERG as new species are evidently identical with the present species. *Frit. campila* and *Frit. tacita*, both described by ESSENBERG as new species, may safely be include in the "*haplostoma*"-group and identified as *haplostoma* or *abjornseni* rather than be treated as distinct species.

13. *Frit. formica*
14. *Frit. pellucida*
15. *Frit. borealis* f. *typica* (=*Frit. borealis* by ESSENBERG)

Frit. delicata ESSENBERG has the tail ending in an acute point; the structure of the trunk is, however, related closely to that of *Frit. borealis* f. *typica* or *Frit. haplostoma*. Probably this is a form attributable to *Frit. haplostoma* having an imperfectly preserved trunk or one belonging to *Frit. borealis* f. *typica* having an imperfectly preserved tail which is shrunk near the distal end.

16. *Frit. borealis* f. *intermedia* (=*Frit. juncea* ESSENBERG, ? *Frit. gigas* ESSENBERG, *Frit. claudaria* ESSENBERG)

Frit. exilis and *Frit. pulchrituda* described by ESSENBERG as new species, are considered safely to belong to the species *borealis* and may be classified as f. *intermedia* or f. *typica*. *Frit. nitida* ESSENBERG and *Frit. brevicollis* ESSENBERG have the tail ending in a pointed tip, but the structure of their trunks resembles very closely that of *Frit. borealis* f. *typica* or f. *intermedia*. It is very possible that these two are nothing but imperfectly preserved specimens of f. *intermedia*, in which the posterior end of the tail fin is shrunk as to be seen ending in an acute tip, because the tail-musculature is rather wider for f. *typica*. *Frit. tenebra* and *Frit. artus*, both having the tail ending in an acute tip and identified by ESSENBERG as new species, may safely be identified as *Frit. borealis* f. *intermedia* or f. *typica*, for the same reason as mentioned above.

17. *Frit. borealis* f. *sargassi* (=*Frit. sargassi* and *Frit. ritteri* by ESSENBERG, *Frit. trigonis* ESSENBERG)

Frit. diafana, *Frit. plana* and *Frit. clava*, all described by ESSENBERG as new species, may safely be identified as *Frit. borealis* f. *sargassi* having a rather narrow tail musculature. *Frit, angularis* and *Frit. velocita* are provided with the tail ending in an acute tip, but the structure of their trunks are just the same as that of *Frit. borealis* f. *sargassi*. Very probably these are imperfectly preserved specimens of *Frit. borealis* f. *sargassi* in which the tail fin is fairly shrunk.

18. *Frit. megachile* (=*Frit. macrotrachela* ESSENBERG and *Frit. dispara* ESSENBERG)

The complete absence of any glandular appendages on the stomach and intestine is common to *Frit. megachile* and two ESSENBERG's species. The distal end of the tail fin is widely cut in, the trunk is very elongate and the ovary and testis are arranged antero-posteriorly in all these three forms.

19. *Frit. venusta* (=*Frit. inverta* ESSENBERG)
20. *App. sicula*
21. *K. tenuis*

Most of ESSENBERG's new species are considered to be included in the "Formenkreis" of *Fritillaria haplostoma* or *Fritillaria borealis*. And these two species are well known by their remarkable variability found in the size of matured individuals, body shape and width of tail musculature. In the group of *Frit. haplostoma*, one end of the variation is represented by a comparatively large typical form which has a very elongate trunk, the posterior end of the oikoplast epithelium being far apart from the stomach, and a very narrow tail musculature, while the other end of the variation is shown by *Frit. arafoera* which has a very short trunk and a fairly wide tail musculature; and *Frit. abjornseni* is considered to be situated near *Frit. arafoera* (TOKIOKA 1955 a and 1956 c). The length of the distal exposed portion of chorda decreases towards *Frit. arafoera*. I have treated *Frit. abjornseni* and *Frit. arafoera* as distinct species. It is, however, very probable that these may be included in the single species represented by *Frit. haplostoma* and treated as intraspecific varieties or forms, when the biometrical and statistical studies are made on many specimens from various localities. Actually BJÖRNBERG and FORNERIS (1955) are treating *abjornseni* as a form of *Frit. haplostoma* against f. *typica* of the species.

The "Formenkreis" of *Fritillaria borealis* was shown in the earlier stage of

the study of appendicularian taxonomy by the following four species: *Frit. borealis* LOHMANN 1896 a, *Frit. sargassi* LOHMANN 1896 b, *Frit. messanensis* LOHMANN 1899 and *Frit. ritteri* AIDA 1907. Later, LOHMANN (1905) united the first two into *Frit. borealis* and subdivided the species into three formae and one variety; they were

Frit. borealis f. *typica* (=*Frit. borealis* LOHMANN 1896)
" f. *intermedia*
" f. *sargassi* (=*Frit. sargassi*)
" var. *allongata*.

Then he rearranged these forms all as formae of *Frit. borealis* (1926).

Frit. borealis f. *typica*
" f. *intermedia*
" f. *allongata*
" f. *sargassi*
" f. *ritteri* (=*Frit. ritteri* AIDA)

Lastly (1931) he revised the classification as follows:

Frit. borealis acuta typica
" " *prolifera*
" *truncata intermedia*
" " *allongata*
" " *crassa*
" " *ritteri*
" " *sargassi*.

All these subspecies, varieties or formae were defined by the combination of various shapes and relative positions of the testis and ovary and different width of the tail musculature, the appearance of the distal end of the musculature and the shape of the shoulder-like basal part of the tail fin. However, the characteristics concerning the tail, which were adopted by LOHMANN as clues to separate forms, are completely continuous one another that any distinct boundaries cannot be discerned. The variations found in the shape of the ovary and testis are also quite continuous. Only the relative position of the testis and ovary seems to be very stable, namely the arrangement of the ovary and testis may be symmetrical or asymmetrical. *Allongata* and *prolifera* features are nothing but deformations found in the symmetrical arrangement, most possibly found in individuals matured in small sizes; while the *crassa* feature is merely a modification of the asymmetrical arrangement, found frequently in small-sized mature individuals. And usually the symmetrical arrangement of the gonad is accompanied with the narrower tail musculature and the asymmetrical arrangement of the gonad is combined with the wider tail musculature in which occurs most commonly the truncate feature of the distal end of the musculature. VERNIÈRES (1933) estab-

lished a new variety *Frit. borealis acuta* f. *typica* var. *mediterranea* which was resembling *Frit. borealis truncata intermedia* very closely, but differing from it in having the tail musculature ending in a pointed tip (p. 42, fig. 18). This variety seems, however, to be treated more reasonably as a *typica*-form side individual of *intermedia*-form. For these reasons, I shortened the classification of *Frit. borealis* into only three forms, f. *typica* with the symmetrical arrangement of the gonad and the very narrow tail musculature, f. *sargassi* with the asymmetrical arrangement of the gonad and the much wider tail musculature and f. *intermedia* with the symmetrical arrangement of the gonad and the tail musculature showing an intermediate feature between f. *typica* and f. *sargassi* (1940). Here, it is not impossible that f. *intermedia* might be included in f. *typica* as a variant mostly occurring in the warm water or in the mixing area between the cold and warm waters. *Frit. messanensis* has been left outside the discussion about the "Formenkreis" of *Frit. borealis* as BJÖRNBERG and FORNERIS (1955) treat this as a distinct

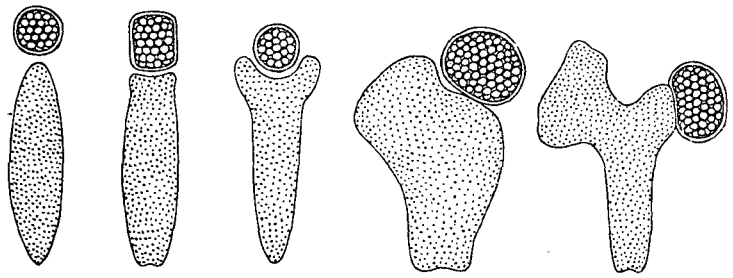

Fig. 1. Schemata of the arrangement of ovary and testis in various forms of *Fritillaria borealis* LOHMANN. 1···f. *typica* and f. *intermedia*, 2···f. *allongata*, 3···f. *prolifera*, 4···f. *crassa*, 5··· f. *sargassi* and f. *ritteri*.

species. But, I feel, in all probability, that this might be a small form of f. *intermedia* with unusually wider tail musculature.

It is very difficult to show exactly what the cause of such morphological variations found in *Frit. haplostoma* and *Frit. borealis* is. Even the variation found in the body size does not seem to be simply explained. However, it is very probable that the variable environment might be favourable to the occurrence of those variants mentioned above. The area covering the pier at the Scripps Institution where ESSENBERG collected her samples is effected by the southward flowing California Current and the northward flowing narrow Davidson Current bordering the coast, and these two currents change their strength from time to time, besides some upwelled water masses may join there at times and make the environment of the area very complicated. Thus, it is very resonable that ESSENBERG found so many variants in specimens of *Frit. haplostoma* and

Frit. borealis collected from this area of complicated environment and named them respectively as distinct species. But, the features characterizing these new species should be treated as the intraspecific variations found in these two species. Among the species listed by ESSENBERG, the occurrence of *O. vanhöffeni*, the species characteristic of the very cold arctic water, must be especially noted.

In the more northern part of the blue-green water, BIGELOW and LESLIE (1930) records the common occurrence of *O. labradoriensis* in July, 1928 in Monterey Bay, the sufficiently abundant catch of *O. dioica* and the questionable occurrence of *O. intermedia*. *O. vanhöffeni* was, however, not found there.

IV. APPENDICULARIANS IN LAGOONS OF BAJA CALIFORNIA

(Table 4)

Considerable numbers of *Oikopleura dioica* were found in four of ten plankton samples collected in Scammon's lagoon situated approximately at 27°45′ N× 114°10′ W, Oct. 9–12, 1955. The water at Stations 10 and 16 was characterized by dominancy of a copepod *Paracalanus*, that of Station 15 B was predominated by *Acartia*, while the sample from Station 15 A contained *Paracalanus*, *Oithona* and *Acartia*.

Stations	Salinity	*O. dioica*	*O. longicauda*
St. 10	36.3‰	13	—
St. 15A	34.7‰	134	1
St. 15B		226	—
St. 16	37.6‰	10	—

Table 4. Occurrence of appendicularians in Scammon's lagoon.

Besides, I had a chance to examine two samples towed respectively at 2 and 3 feet deep for five minutes near North End of Manuela lagoon, situated in a short distance north to Scammon's lagoon, on Oct. 12, 1952. These samples seemed to consist nearly of the pure *Acartia* population and I could not find any appendicularians in them. For positions of sampling stations, see Fig. 24 in my paper of 1959.

V. PELAGIC TUNICATES IN THE SHELLBACK AREA

(App. Tables 4–5, Tables 5–6 and Text-figs. 2–3)

Thirty-six species were found in the collection of the Shellback Expedition. Fritillarians were rather scarce in the collection, this is probably due to the fact that the samples were towed by a large net. *O. longicauda* was the commonest species and followed by *O. cophocerca*, *O. rufescens* and *O. fusiformis*. *O. albicans*

occurred also in a little abundance. The ratio F/L is very low, mostly less than 0.10; but the real value might be much higher, because the damaged specimens of oikopleurids were very abundant in this collection and these might include a significant number of *O. fusiformis*. The distribution of F/L in the Shellback

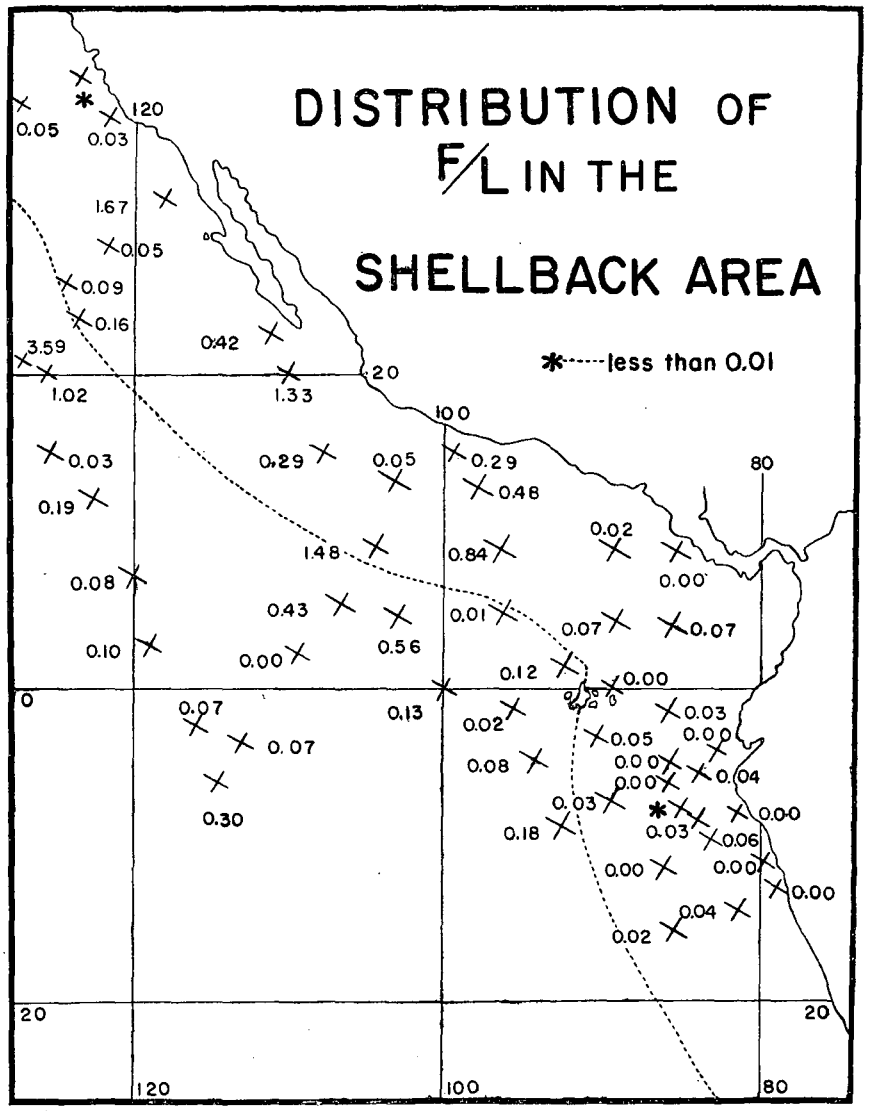

Fig. 2. Distribution of F/L in the Shellback area.

area is shown in Fig. 2. The value seems to trend towards the slight decrease near the coast; this may be seen rather easily in Table 6, in which stations are divided into the inshore and offshore groups by drawing a line about 600 miles

apart from and running parallel to the coast line and values at stations in respective groups are arranged so as to make the comparison easier. The above-mentioned 600 mile line is shown by a broken line in Fig. 2. Of fritillarians, only *Frit. pellucida* and *Frit. borealis* f. *sargassi* occurred in significant numbers, *Frit. formica* f. *digitata* and *Frit. haplostoma* were as scarce as *Frit. tenella* and *Frit. venusta.*

Of doliolums, *Doliolum denticulatum* occurred most frequently and abundantly. *Doliolum nationalis* and *Doliolina intermedia* occurred commonly, too, but much

Number of sampling stations	48	
0	10	44
*–0.10	21	
0.11–0.50	11	
0.51–1.00	2	
1.01–2.00	4	4

Table 5. Occurrence of respective values of F/L in the Shellback area.

	Inshore stations		Offshore stations	
Number of stations	36		18	
0	10	75%	1	50%
*–0.10	17		8	
0.11–0.50	5	17%	6	39%
0.51–1.00	1		1	
1.01–2.00	3	8%	1	11%
>2.01	—		1	

Table 6. Occurrence of respective values of F/L in the inshore and offshore waters in the Shellback area and adjacent region.

less frequently and less abundantly than *D. denticulatum.* The dense population of *Doliolum nationalis* was found at SB 137 and a pretty dense one at SB 115. *Dolioletta gegenbauri* var. *tritonis* occurred at some stations in significant numbers, most abundantly at SB 118 and then at SB 122 and SB 137. The distribution of *D. nationalis* seems to trend towards the increase in the inshore water in this area. *D. gegenbauri* var. *tritonis* also occurred more frequently in the inshore water than in the offshore water and consequently was often collected together with *D. nationalis* (occurrence together with *D. nationalis* 10: occurrence inde-

pendent of *D. nationalis* 4). The collection of the "Vettor Pisani" contained *Doliolum nationalis, Dolioletta gegenbauri* var. *tritonis* and *Doliolina krohni* from the waters along the Chilean coast, *Doliolum denticulatum* and *Doliolina krohni* from

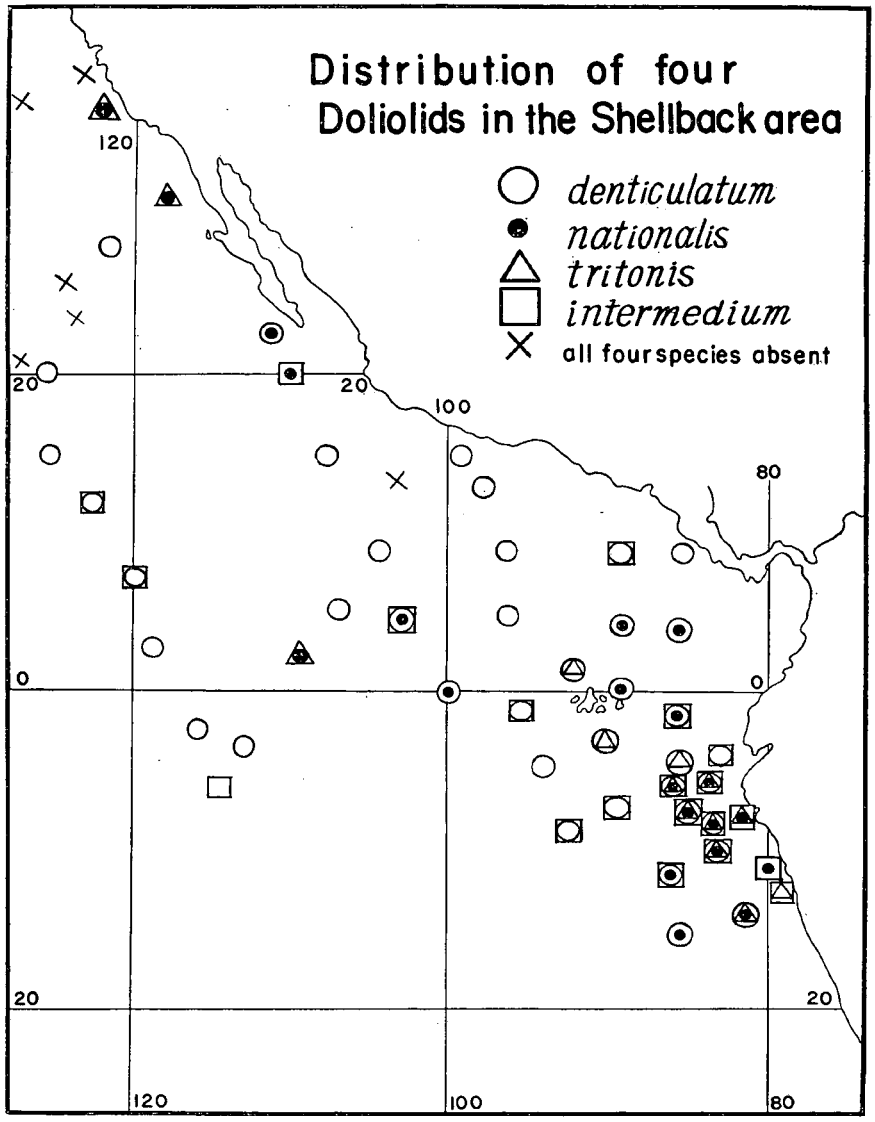

Fig. 3. Distribution of four doliolids in the Shellback area.

the waters around the Galapagos Islands and *Doliolum denticulatum, Doliolum nationalis* and *Dolioletta gegenbauri* var. *tritonis* from the Gulf of Panama (BORGERT 1896). This seems to show the frequent occurrences of *Doliolum nationalis* and

Dolioletta gegenbauri var. *tritonis* in the inshore waters. *Thalia democratica* was the most abundant of all salpas and followed by *Salpa cylindrica* and *Iasis zonaria*. Of the solitary form of the first species, var. *orientalis* occurred slightly more frequently than typical forms, although individuals were fewer in the former than in the latter.

VI. PELAGIC TUNICATES OF THE TRANSPAC EXPEDITION

(App. Tables 6–7, Table 7 and Text-figs. 4–5)

Putting two subarctic species, *O. labradoriensis* and *Frit. borealis* f. *typica*, aside, *O. longicauda* was the commonest species and next *O. fusiformis*. *Frit. borealis* f. *sargassi* and *O. rufescens* were also pretty common, then *O. dioica*; *O. cophocerca*, *Frit. pellucida*, *Steg. magnum*, *O. graciloides* and *O. albicans* occurred in significant numbers, but much less than preceding species. The scarcity of *M. huxleyi* and the absence of *Frit. tenella* and *Frit. venusta* in this collection are

Sections	NW		NWM		NM		NEM		NE	
Number of samples	24		14		13		4		7	
0/0	—		—		—		—		—	
0.00	1	20	—	8	—	3	—	1	1	3
<0.10	2		—		—		—		1	
0.11– 0.50	13		6		1		—		1	
0.51– 1.00	4		2		2		1		—	
1.01– 2.00	4	4	1	6	3	10	—	3	1	4
2.01– 5.00	—		1		3		1		1	
5.01–10.00	—		—		1		—		—	
>10.01	—		1		—		—		1	
∞	—		3		3		2		1	

Table 7. Occurrence of respective values of F/L in sections of the North Pacific surveyed by the Transpac Expedition and other expeditions. For the position of respective sections see Figs. 4 and 5.

probably due to the fact that most stations were situated in the area of higher latitudes more northern than the subtropical zone.

The distribution of F/L seems to show the trend towards the increase in the central part of the North Pacific. This does not mean the increase of *O. fusiformis* individuals in the central part of the North Pacific. Rather, the absolute abundance of *O. fusiformis* may be larger in the areas not far from the coast. Then this can be accepted as to mean the rapid drop of *O. longicauda* population

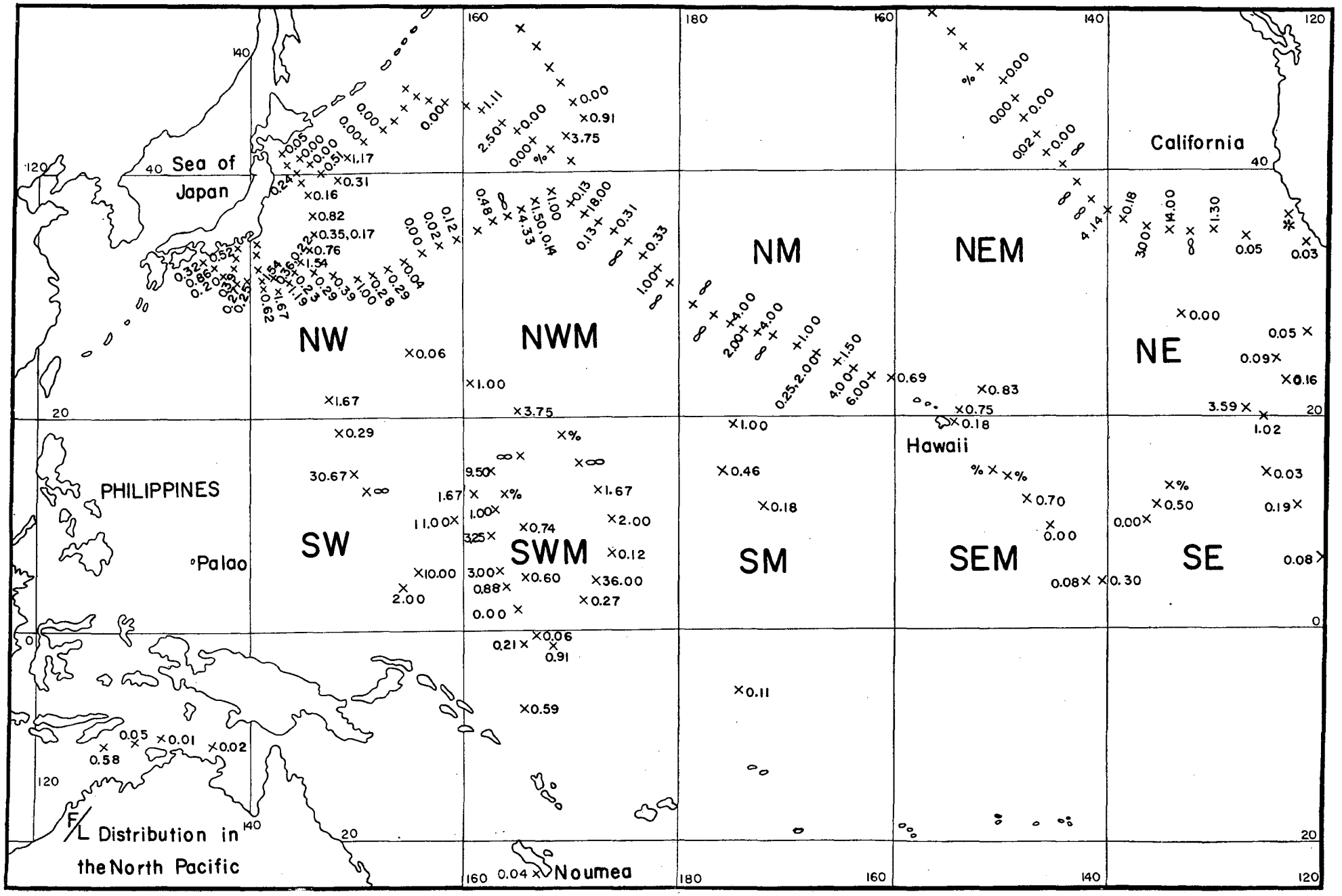

Fig. 4. Distribution of F/L in the North Pacific.

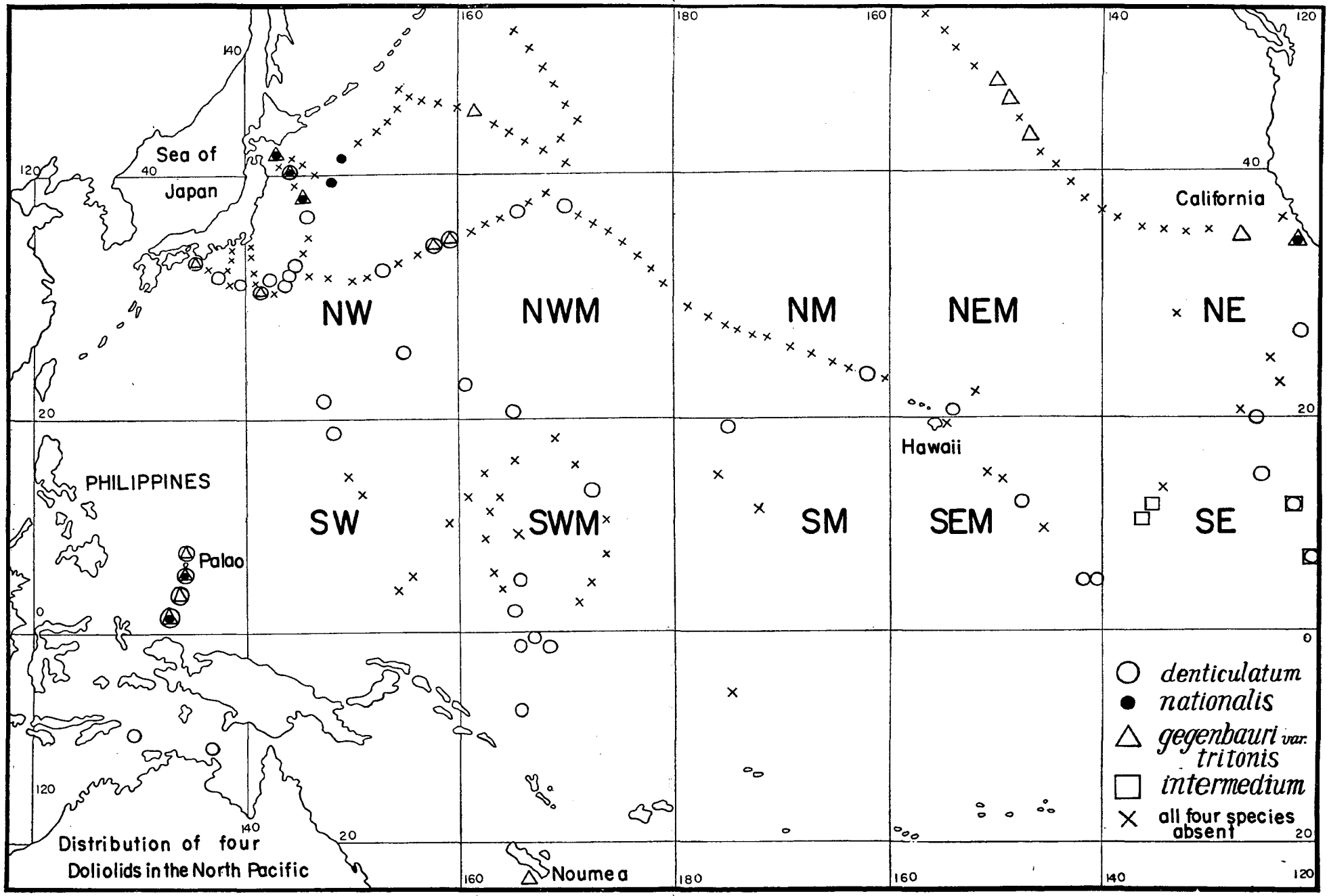

Fig. 5. Distribution of four doliolids in the North Pacific.

in the central North Pacific. The area where *O. longicauda* greatly predominated over *O. fusiformis* was much wider in the western Pacific than in the eastern Pacific.

Thalia democratica was the commonest of all thaliaceans as in other collections. There were 10 samples in which the solitary form of this salp was found, the typical form occurred in five of them and the variety *orientalis* did in seven. *Doliolum denticulatum* was distributed very widely and occurred frequently (Fig. 5), while the distribution of *D. nationalis* was confined to the area near the coast, although sometimes it occurred in very dense populations as seen in samples from Stations 74, 76 and 78. *Dolioletta gegenbauri* var. *tritonis* occurred also rather commonly, but its distribution did not seem to be extended to the central part of the North Pacific. The frequent occurrence of this doliolid seemed to be confined to the area near the coast where *O. longicauda* was maintaining its dominancy or to the area along the mixing region between the subarctic water and the warm water.

VII. PELAGIC TUNICATES OF THE MIDPAC EXPEDITION

(App. Tables 8-9)

Twenty-six species of appendicularians occurred in the collection. The most abundant one was *O. longicauda* which was then followed by *O. rufescens*, *O. cophocerca* and *O. fusiformis*. *M. huxleyi* and *Steg. magnum* were also found commonly. Of fritillarians, *Frit. borealis* f. *sargassi* was the commonest, and *Frit. pellucida* and *Frit. formica* f. *digitata* followed it. *Frit. haplostoma* was rather scarce in this collection, its value *Frequency of Occurrence*×*Mean Percentage* was smaller even than that of *Frit. tenella*. The values of F/L seemed to be lowered towards the south in the section SM and they were very small near the coast in the section NE (see Fig. 4); the values in sections SEM and SE were not large, either.

Thalia democratica was the commonest salpa; of solitary forms, var. *orientalis* was met with much more frequently than the typical form was (solitary forms of the typical form occurred in 6 samples, solitary forms of var. *orientalis* in 17 samples, both forms occurred in 4 samples). *Doliolum denticulatum* was rather common, while *D. nationalis* was quite absent in the present collection. *Doliolina intermedia* occurred in significant numbers at only Stations 7 and 8.

VIII. PELAGIC TUNICATES OF THE EQUAPAC EXPEDITION

(App. Tables 10 and 11)

Twenty-six species of appendicularians were found in five samples of the Equapac Expedition. *O. longicauda* and *Frit. pellucida* were the most prominent species in this collection and followed by *O. fusiformis*, *O. rufescens* and *Frit. tenella*. *Frit. borealis* f. *sargassi* occurred also in significant numbers. *O. cophocerca*,

M. huxleyi, *Steg. magnum* and *Frit. venusta* were pretty common, though much less than preceding species. F/L varied in the range from 0.11 to 0.74, being 0.45 on an average. *Thalia democratica* was the commonest thaliacean, solitary forms of both the typical form and var. *orientalis* occurred at the similar frequency and in very similar numbers. *Doliolum denticulatum* occurred rather commonly, but none of *D. nationalis*.

IX. PELAGIC TUNICATES COLLECTED BY THE SYUNKOTU-MARU IN MAY-JUNE 1954

(Appendix Table 12, Tables 8–9, see also Table 1)

The area surveyed by the Syunkotu-maru covers most parts of the Marshall Islands and is shown in my previous paper* dealing with chaetognaths of the area. The results of the examination on appendicularians collected during the cruise have already been published in my paper of 1955 d. Important oikopleurids were *O. fusiformis*, *O. longicauda*, *M. huxleyi*, *Steg. magnum* and *O. rufescens*;

	North Equatorial Current	Counter Equatorial Current	South Equatorial Current
Number of samples	17	7	4
O. longicauda	71	100	100
O. fusiformis	88	100	75
O. rufescens	47	71	100
O. cophocerca	12	—	75
M. huxleyi	82	86	100
Steg. magnum	24	100	100
Frit. haplostoma	—	43	—
Frit. formica	47	24	—
Frit. pellucida	35	43	—
Frit. borealis f. *sargassi*	12	43	25

Table 8. Frequency of occurrence of important species in respective currents remarkable in the area surveyed by the Syunkotu-maru.

while fritillarians were represented mainly by *Frit. pellucida*, *Frit. formica* and *Frit. borealis* f. *sargassi*. The largest total of appendicularian individuals per each haul was found in samples from the South Equatorial Current. The ratio F/L seemed higher in the northern part than in the southern part of the surveyed area (Table 9).

Of 13 distinctly identified species of salps, *Thalia democratica*, *Salpa cylindrica* and *Cyclosalpa pinnata* were prominent ones and followed by *Salpa fusiformis*

* TOKIOKA, T. (1955): On some plankton animals collected by the Syunkotu-maru in May-June, 1954. I. Chaetognatha. Publ. Seto Mar. Biol. Lab., IV (2-3), pp. 223-225.

which was fairly fewer than the above-mentioned three species. The solitary form of the typical *Thalia democratica* occurred at the frequency of 25%, while that of var. *orientalis* was met with at the frequency of 50%; three of the eighteen occurrences of the solitary form of this salpa were represented by both of the typical form and var. *orientalis*. *Doliolum denticulatum* occurred at the frequency of 32%, while none of *D. nationalis* was found in the collection.

	North Equatorial Currett		Counter Equatorial Current		South Equatorial Current	
Number of samples	17		7		4	
0/0	2		—		—	
0.00	—	5	—	2	1	4
<0.10	1		—		1	
0.11- 0.50	2		1		1	
0.51- 1.00	2		1		1	
1.01- 2.00	3	10	1	5	—	0
2.01- 5.00	1		2		—	
5.01-10.00	1		1		—	
>10.01	2		1		—	
∞	3		—		—	

Table 9. Occurrence of respective values of F/L in different currents in the area surveyed by the Syunkotu-maru.

X. PELAGIC TUNICATES OCCURRING IN THE SURROUNDING WATERS OF THE PALAO ISLANDS

(App. Tables 15–17, Tables 10–11, Text-figs. 6–8)

While I was staying at the former Palao Tropical Biological Station located on Korôru Island of the Palao Islands during the period from May 1940 to January 1941, I had a chance to examine 62 plankton samples mostly collected at various parts of Iwayama Bay (Fig. 8) which was called a lagoon in the lagoon of the Palao Islands and some other stations in the lagoon. Besides, I examined two series of plankton samples collected by the former Japanese fishery experiment station at Palao with KITAHARA's quantitative net from 50 m to the surface. One consisted of 104 samples collected in the neighbouring waters of the islands in the years 1939–40, while the other included 45 samples collected during the Palo-New Guinea cruises 1939–40. The data about fifty of the former and thirty-one of the latter were recorded in a form to be available for the present studies. All available data concerning the pelagic tunicates are given here in App. Tables 15–17.

	North Equatorial Current	Counter Equatorial Current	South Equatorial Current	Lagoon water
Number of samples	46	19	16	62
O. longicauda	61	100	94	97
O. intermedia	—	21	—	—
O. fusiformis	76	74	94	2
O. fusiformis f. *cornutogastra*	28	26	19	87
O. graciloides	4	5	—	—
O. dioica	7	21	38	81
O. rufescens	85	89	100	58
O. cophocerca	52	63	75	2
M. huxleyi	39	63	50	—
Steg. magnum	72	79	88	3
P. verticalis	9	26	—	—
Frit. haplostoma	65	58	69	60
Frit. abjornseni	13	16	13	5
Frit. aberrans	4	5	—	—
Frit. formica f. *digitata*	65	74	94	2
Frit. gracilis	9	—	—	—
Frit. fraudax	—	11	—	—
Frit. pellucida	65	47	56	6
Frit. borealis f. *intermedia*	2	—	—	—
Frit. borealis f. *sargassi*	91	79	94	32
Frit. megachile	—	—	6	—
Frit. tenella	—	5	—	—
Frit. venusta	—	5	—	—
T. fertilis	4	11	—	—
App. sicula	7	26	50	66
K. tenuis	—	11	—	—
Number of species	20	23	15	13

Table 10. Frequency of occurrence of respective species in different currents and the lagoon water, at and near the Palao Islands.

	North Equatorial Current	Counter Equatorial Current	South Equatorial Current	Total
O. longicauda	—	6	7	13
O. fusiformis	2	—	2	4
O. rufescens	2	—	3	5
O. cophocerca	—	—	—	0
M. huxleyi	—	1	—	1
Steg. magnum	—	—	—	0
Frit. haplostoma	1	—	—	1
Frit. formica f. *digitata*	1	—	1	2
Frit. pellucida	—	—	—	0
Frit. borealis f. *sargassi*	—	—	—	0

Table 11. Abundant occurrences of 10 important species in respective currents in the neighbouring waters of the Palao Islands.

Appendicularians

Species occurring in the open waters: In all, 26 species occurred in this region (App. Tables 16–17, Table 10). Important forms were *O. longicauda, O. fusiformis, O. rufescens, O. cophocerca, M. huxleyi, Steg. magnum, Frit. haplostoma, Frit. formica, Frit. pellucida* and *Frit. borealis* f. *sargassi*. Among *Oikopleura, O. longicauda* is the commonest species and followed by *O. rufescens* and *O. fusiformis*. *Frit. borealis* f. *sargassi* occurred very frequently, but never in abundance. Relative abundance of *O. longicauda* seemed to be slightly lowered in the North Equatorial Current as seen in Table 11. The increase of *O. dioica* towards south (Table 10) is considered to show the trend towards the increase of the littoral character in the southern waters.

Species occurring in Iwayama Bay: Thirteen species were found in the collection made in the Bay (Appendix Table 15). Important forms of *Oikopleura* were *O. longicauda, O. fusiformis* f. *cornutogastra, O. dioica* and *O. rufescens*, and significant species of *Fritillaria* were *F. haplostoma* and *F. borealis* f. *sargassi*, besides *App. sicula*. The frequency of abundant occurrence in these species was as follows:

O. longicauda 53%
O. fusiformis f. *cornutogastra* 19%
O. dioica 6%
O. rufescens 6%
Frit. haplostoma 8%
Frit. borealis f. *sargassi* 2%
App. sicula 3%

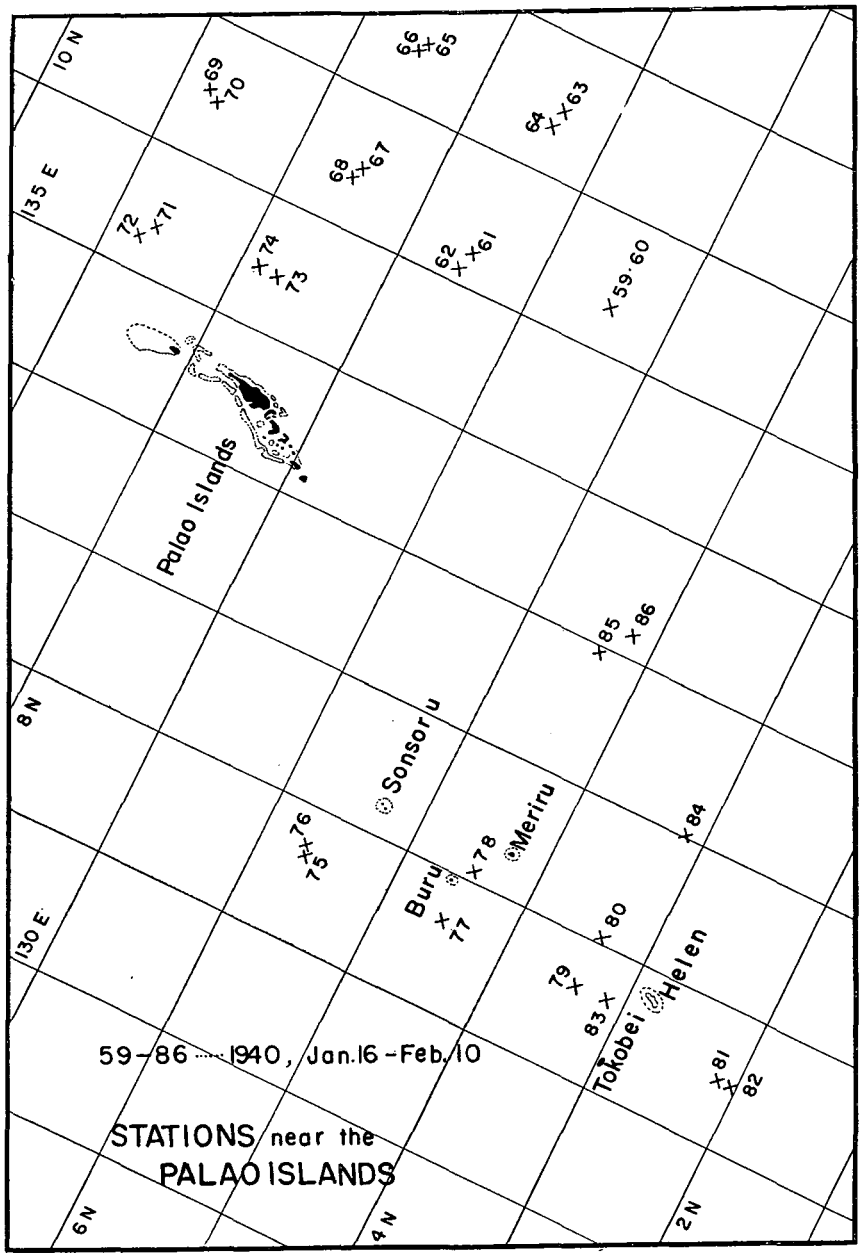

Fig. 6. Sampling stations in the neighbouring waters of the Palao Islands.

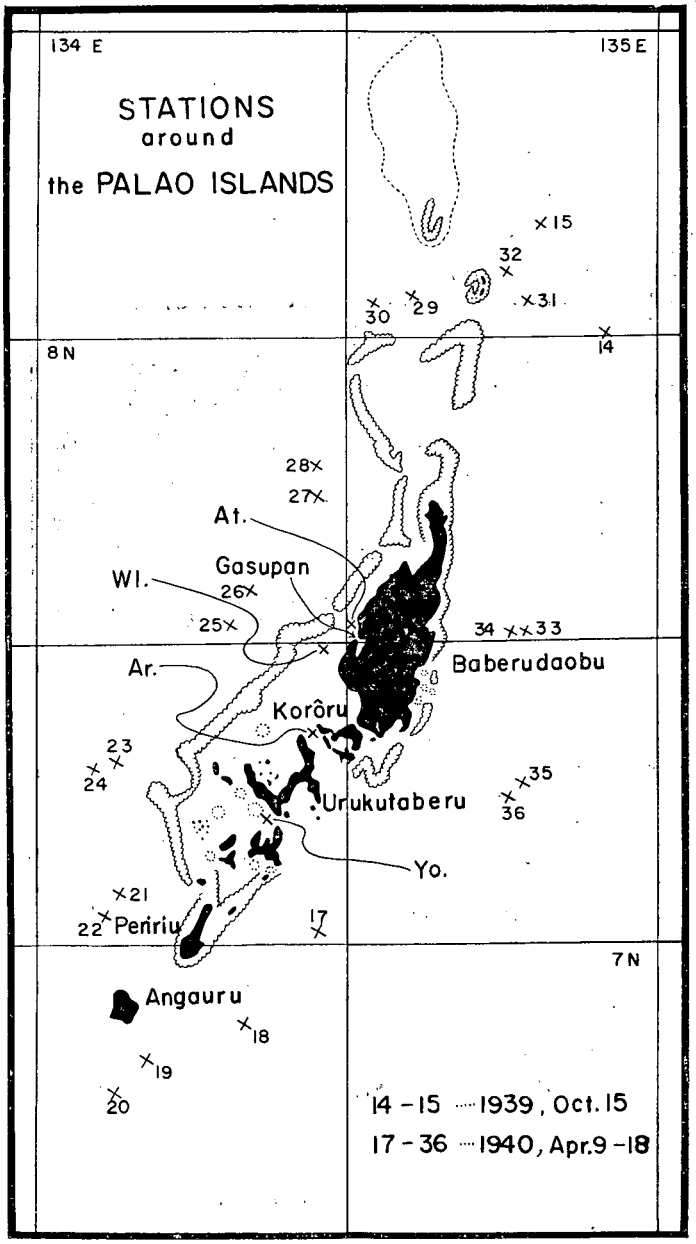

Fig. 7. Sampling stations around the Palao Islands.
Ar.···Station off Arakabesan, At.···Station off Arumatenguru,
Wl.···Station in the West Lagoon, Yo.···Station in the Yô Channel.

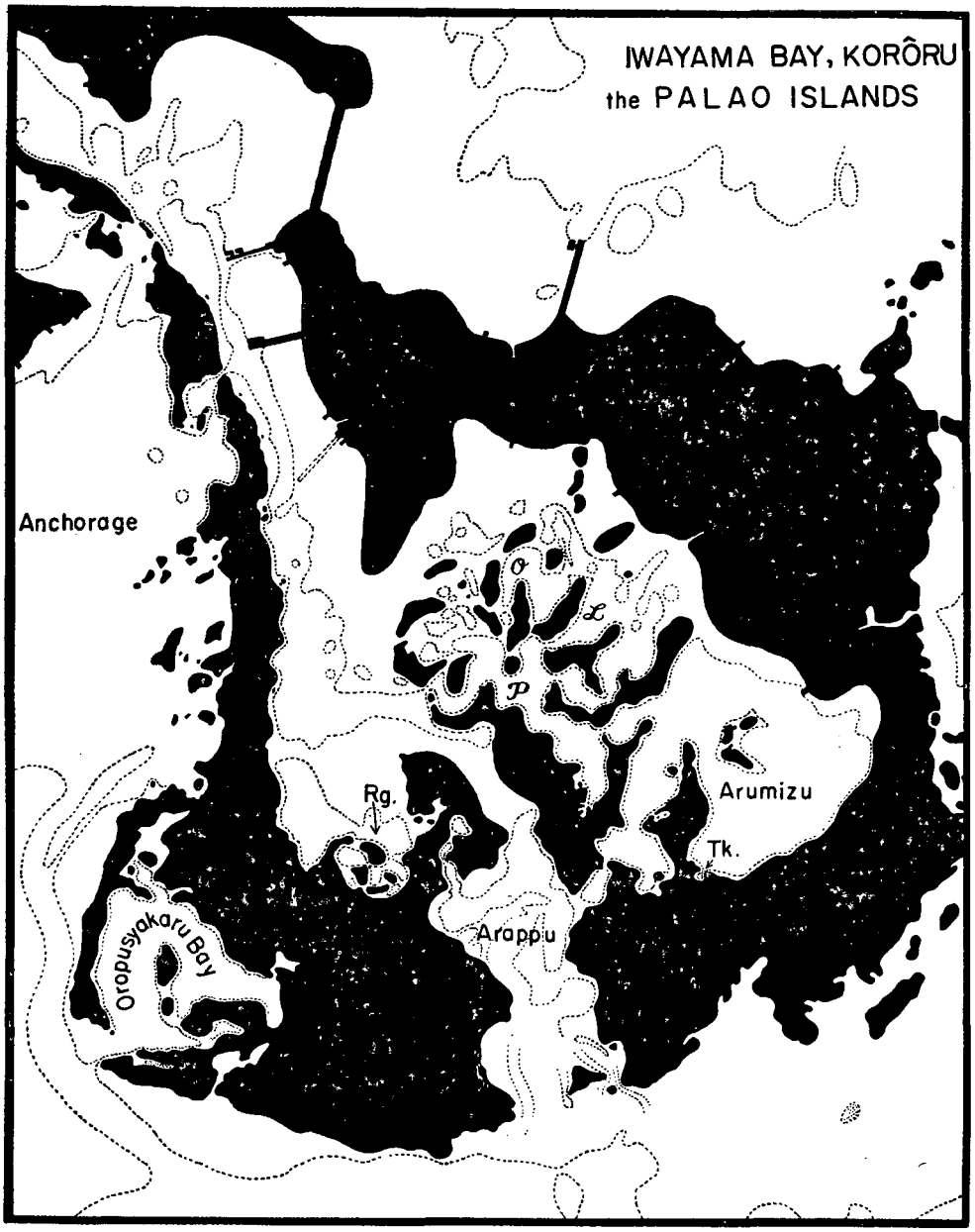

Fig. 8. Iwayama Bay of Korôru Island, the Palao Islands.
Rg.···Ryûgû Inlet, Tk.···Tukikagetan Inlet.

Typical form of *O. fusiformis*, *O. cophocerca*, *Steg. magnum*, *Frit. formica* f. *digitata*, *Frit. pellucida* and *Frit. abjornseni* occurred only insignificantly. Most of these species, excepting the last one, are oceanic water-forms and their frequent occurrence was confined to such areas as Anchorage, Arappù, off Arakabesan and the West Lagoon where the water was strongly affected by the influx of the oceanic water. The exact distribution of *Frit. abjornseni* is not yet known fully, although the species is regarded by some authors as a neritic form (BJÖRNBERG & FORNERIS 1956 a, TOKIOKA 1956 c).

The distribution of the seven important species in the Bay: *O. dioica*—This neritic or inlet water-species was distributed nearly evenly in the Bay and found richly even in the inner-most part of the North West Inlet of Oropusyakaru Bay and also in Gasupan Bay where this was the sole appendicularian found there. Seasonal fluctuation of its population was quite insignificant. The density in the West Lagoon was less prominent than in other more protected areas.

O. rufescens, *Frit. haplostoma* and *Frit. borealis* f. *sargassi*—These oceanic water-forms were found in most areas of the Bay, although significant occurrences were not observed in strongly protected portions of the Bay such as divisions O, P and Ryûgû Inlet for the first two species and O, L and Ryûgû Inlet for the last one.

O. longicauda—Originally this is also an oceanic water-form, although it was found survived in a quite perfect condition in the inner parts of the Bay so that it predominated over any of other appendicularians, even *O. dioica*, in most parts of the Bay. It was distributed nearly evenly in the Bay, but the population seemed to be lowered in some degree in the division O which was considered to be the most protected part of the Bay. Gasupan Bay on the western coast of Palao Island was the only place where this species was not found at all. This species and also other oceanic water-forms appeared in the Bay most abundantly in the latter half of May and in July when the influx of the oceanic water into the Bay was considered to be very prominent.

O. fusiformis f. *cornutogastra*—This was very abundant in the Bay next the preceding species. It was distributed nearly evenly in the Bay, although it occurred especially numerously off Arakabesan and in the anchorage. Gasupan Bay was the only inlet where this species was not found at all. The population scarcely showed the seasonal fluctuation in the Bay. The frequency of occurrence of thir form in the open waters around the islands seemed to decrease considerably as shown in Table 10. Such features of the distribution and occurrence may possibly be accepted as indicating that the form is a lagoon water-form like *Sagitta oceania* GRAY, a well known inhabitant of the lagoon water throughout the tropical Pacific islands. Of course, this form can survive in the open sea water and actually it has been reported as being distributed very widely in the warm oceanic water as in the case of *O. dioica*, although there it is found very

sparsely and less frequently.

App. sicula—This was also distributed very widely and nearly evenly throughout the Bay, although it was generally not so abundant as *O. longicauda*, *O. fusiformis* f. *cornutogastra* or *O. dioica*. It was found even in the innermost part of the North West Inlet of Oropusyakaru Bay, but it did not occur in Gasupan Bay. There was observed a diatom bloom, consisting chiefly of *Lauderia annulata*, *Rhizosolenia imbricata*, *Chaetoceros affinis*, *Chaetoceros Lauderi*, *Chaetoceros pseudocurvisetus* and *Biddulphia sinensis*, in the area covering L, O and P divisions of the Bay during the period extending from the end of May to the beginning of July. *O. longicauda* and *O. fusiformis* f. *cornutogastra* were very scarce in these parts of the Bay during this diatom propagation. ESSENBERG (1922) mentioned also that the continuing high density of microplankton brought the remarkable decrease of appendicularians in the San Diego region. *App. sicula* was, however, maintained in these parts as usual even during the diatom bloom; rather its maximal populations throughout the observations made in the Bay were observed in divisions L and P during this season. The fact that no repulsion was seen between *App. sicula* and the dense diatom population and the peculiarity of the distribution that the frequency of occurrence of this species was higher in the Bay than in the surrounding waters of the islands and in the latter it increased towards the South Equatorial or the New Guinea Coastal Current, where the neritic nature of the water was considerably remarkable, seem to show the possibility that *App. sicula* may belong to the neritic form rather than to the pure oceanic species. This species has been reported as being distributed very widely in all tropical waters (FOL 1872, 1874; LANGERHANS 1880, LOHMANN 1896 b, 1909 b, 1931; LOHMANN & BÜCKMANN 1926, ESSENBERG 1926), but occurring in great abundance near the estuary of the Amazon and off the west coast of Africa in the region of Sierra Leone. According to BERNARD (1958), a large number of *App. sicula* were caught by M. CACHON in September, 1953 in the inner portion of the Bay of Alger. The range of the salinity throughout the recorded localities of this species is relatively wide, 29.80–37.30‰. These features seem to support the above-mentioned idea.

Throughout the whole surveyed sections of the Bay and the adjacent areas, appendicularians occurred in all plankton samples but a single one collected off Arumatenguru where the water was heavily polluted by the waste water shed from the aluminium mine. On one hand such oceanic water-forms as *O. longicauda* and others which were very common in the surrounding waters of the islands penetrated into even the inner-most parts of the Bay and on the other hand a considerable number of an inlet water-form, *O. dioica*, was maintained in the Bay; besides those, a possible lagoon water-form, *O. fusiformis* f. *cornutogastra*, and a probable neritic water-form, *App. sicula*, were distributed evenly in the Bay in fairly prominent densities. The pure inlet water population consisting solely of *O. dioica* was found only in Gasupan Bay. The abundant occurrence of appen-

dicularians and the dense diatom vegetation seemed to repulse each other in the Bay, but for *App. sicula.* However, the dense population of dinoflagellates did not seem to be always repulsive against appendicularians. For instance, in the red water caused by *Ceratium furca eugramma* and appeared on May 18, 1940 in Ryûgû Inlet, oikopleurids, especially *O. fusiformis* f. *cornutogastra*, were extremely scarce; whereas considerable numbers of them were observed in the dense population of *Dinophysis homunculus* var. *tripos* appeared in the end of May in the Division of Arumizu.

Thaliaceans

Three salps occurred in the surveyed area, they were *Brooksia rostrata*, *Salpa cylindrica* and *Thalia democratica*, of which the last one was the commonest. In fifty plankton samples collected in the neighbouring waters of the Palro Islands, *Thalia democratica* occurred in 14 samples, six of which included the solitary forms. Two of the six occurrences of the solitary form were represented by the typical form, three by var. *orientalis* and another contained both of the typical form and var. *orientalis*. No salps occurred in Iwayama Bay. Three species of doliolums were identified in the material. They were *Doliolum denticulatum*, *Doliolum nationalis* and *Dolioletta gegenbauri* var. *tritonis*. The most important

Frequency of Occurrence of *Doliolum denticulatum*	
North Equatorial Current (46 samples)	37%
Counter Equatorial Current (19 samples)	73%
South Equatorial Current (16 samples)	81%

species in the open waters was *Doliolum denticulatum* which occurred also in Iwayama Bay once at the division of Arumizu. *Doliolum nationalis* was found only in three of 81 samples, two of which were Stations 31 and 32 situated in the North Equatorial Current just near the Palao Islands, while another Station 15 was situated in the New Guinea Coastal Current. This did not occur in Iwayama Bay. *Dolioletta gegenbauri* var. *tritonis* was fairly abundant, but much less than *Doliolum denticulatum*. However, it was found in Iwayama Bay in a very perfect living state as seen in two abundant occurrences in the Division L.

XI. PELAGIC TUNICATES OCCURRING IN THE JAPANESE AND ITS NEIGHBOURING WATERS

(App. Tables 18–19, Tables 12–21 and Text-figs. 9–12)

1) *Pelagic tunicates in the plankton collection made by a Japanese survey ship in the waters off the north-eastern part of Honsyû Island and presented to the Transpac Expedition* (Appendix Table 18, Table 12 and Text-figs. 9–10).

The area where the collection was made is shown as A in Figs. 9–10. The northern part of this area belongs to the mixing region between the cold Oyasio and the warm Kurosio and in two samples form this mixing region there occurred the following forms:

Stations	J3	J9
O. longicauda	40	48
O. fusiformis	—	1
O. dioica	—	1
O. labradoriensis	2	—
Oikopleurid damaged	1	—
Frit. borealis f. *typica*	—	1

Table 12. Appendicularian populations in two samples from the mixing region.

In the warm water-region of this area, occurred eighteen forms, of which *O. longicauda* was the commonest one. *O. fusiformis* and *O. rufescens* also occurred frequently, but much less abundantly. *Frit. borealis* f. *sargassi* was the dominant-most fritillarian and followed by *Frit. formica* f. *digitata*. *O. cophocerca* and *Frit. pellucida*, both occurring rather abundantly in the tropical waters, were very scarce in the collection. *M. huxleyi* was not found in the collection. *Frit. venusta* and *Frit. tenella* did not occur in any samples, either. F/L was low, less than 1.00 at the maximum, but usually less than 0.48 and 0.18 on an average. In this area, *Doliolum nationalis* was much commoner than *Doliolum denticulatum*. *Dolioletta gegenbauri* var. *tritonis* occurred at four of 19 stations. Solitary forms of *Thalia democratica* comprised both the typical and *orientalis* forms in this collection.

2) *Pelagic tunicates in the plankton collection made by the Sôyô-maru in the years 1934 and 1937–39* (Appendix Table 19, Text-figs. 9–10).

The samples of this collection were not examined completely, only a small part was taken out of each sample for examination. Consequently the results of the examination shown in App. Tables 19 *1–2* and Figs. 9–10 are considered as only contributing to make a rough outline of distributions of identified species and the value F/L. Lower F/L along the coasts of Japan and the continent, comparatively abundant occurrence of *O. rufescens* and *M. huxleyi* in the southern waters and the wide distribution of *Doliolum denticulatum* in the oceanic waters against those of *Doliolum nationalis* and *Dolioletta gegenbauri* var. *tritonis*, rather confined to the coastal waters, may be accepted as trends discerned on these data. The commonest salpa was *Thalia democratica*.

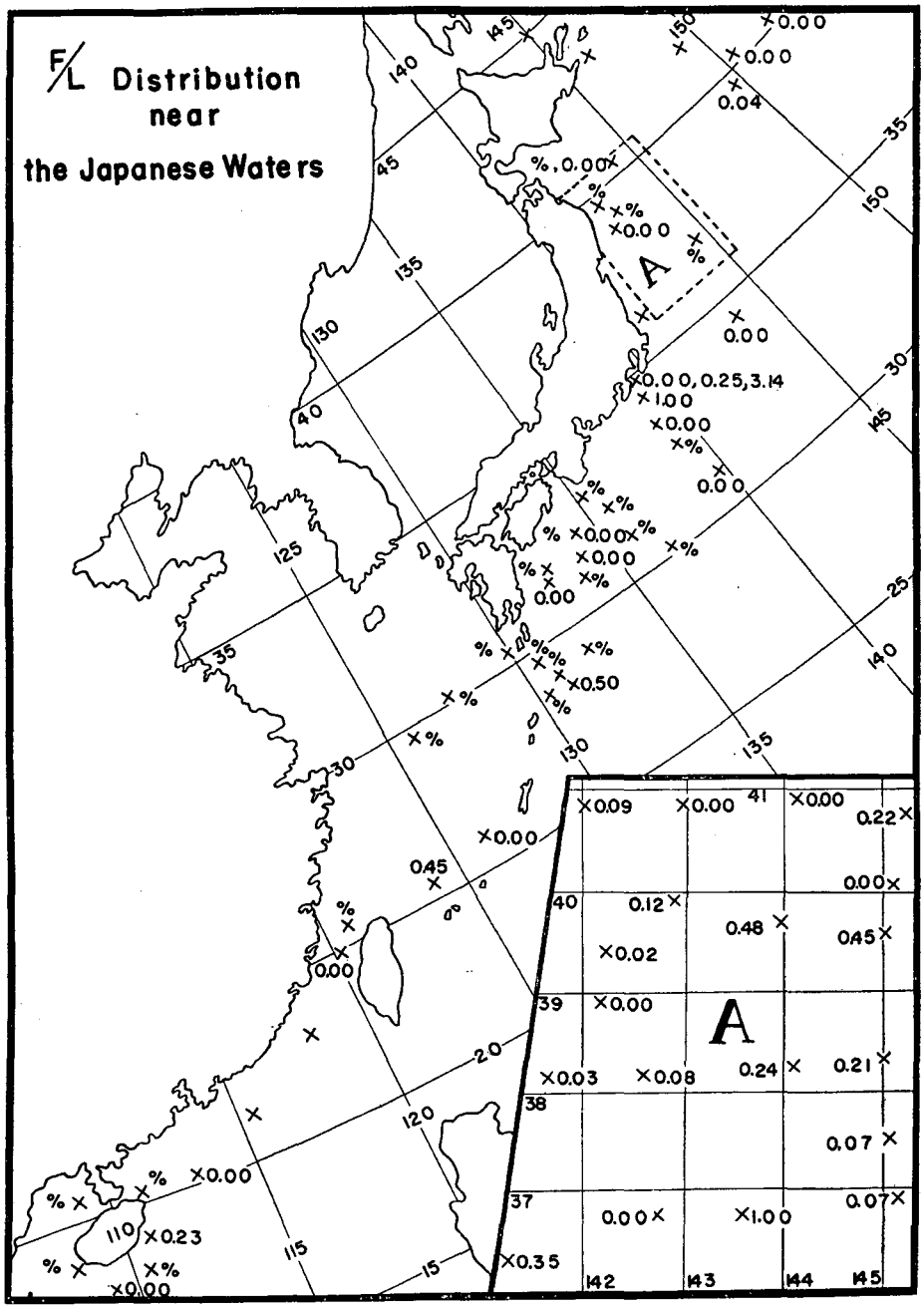

Fig. 9. Distribution of F/L in the Japanese and its neighbouring waters. % indicates that both *O. longicauda* and *O. fusiformis* were absent.

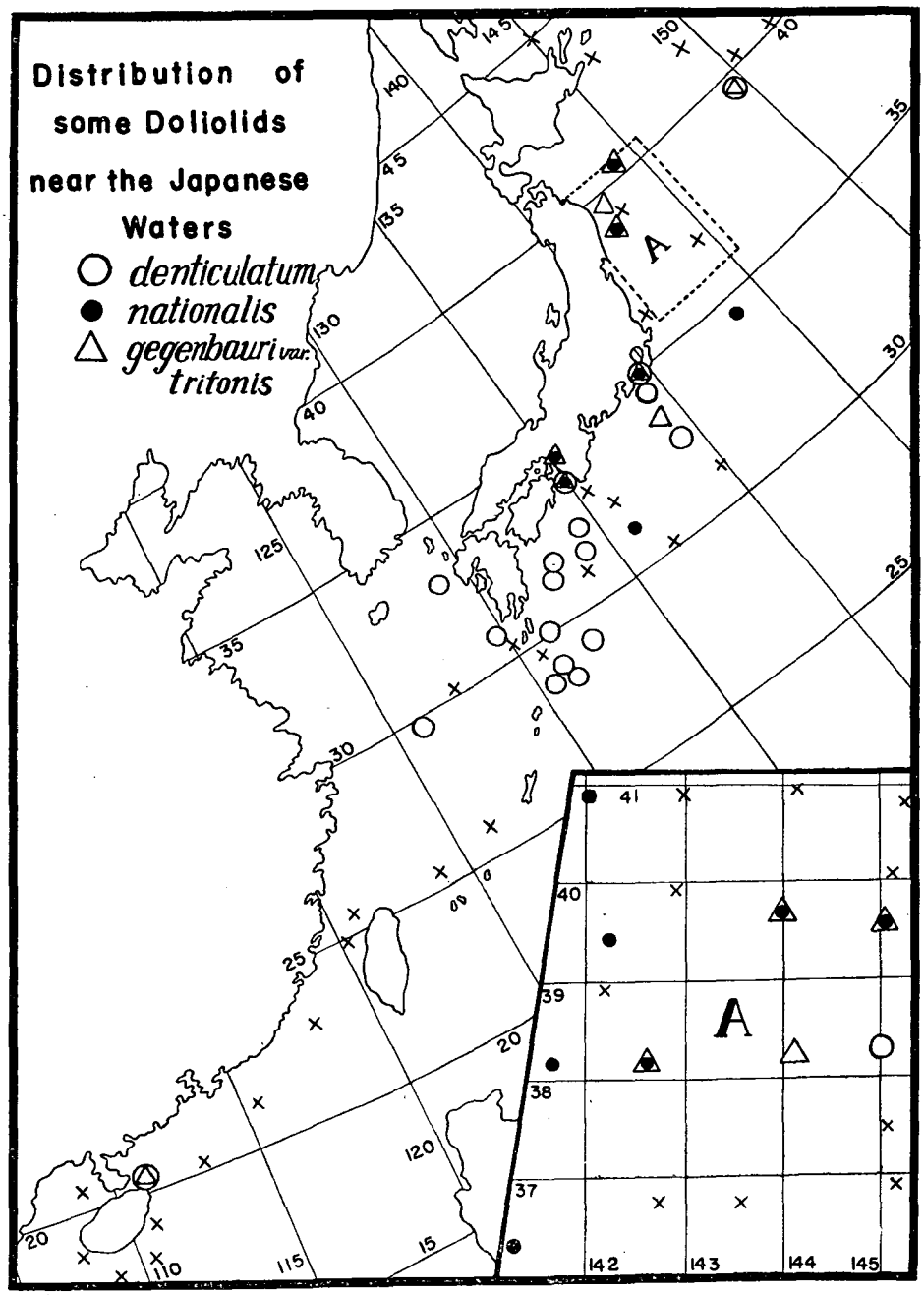

Fig. 10. Occurrences of *Doliolum denticulatum*. *Doliolum nationalis* and *Dolioletta gegenbauri* var. *tritonis* in the Japanese and its neighbouring waters.

	April 26–28		July 25		September 25–27	
	Surface hauls	Vertical hauls	Surface hauls	Vertical hauls	Surface hauls	Vertical hauls
O. longicauda	7644	9200	1166	6110	4800	5810
O. fusiformis	—	—	5795	528	1633	755
O. fusiformis f. *cornutogastra*	—	—	—	30	113	20
O. gracilis	—	—	—	12	—	67
O. dioica	2318	728	1575	6	—	*
O. rufescens	—	—	—	554	1575	655
O. parva	—	—	—	35	—	11
O. cophocerca	—	—	—	18	16	67
O. labradoriensis	—	99	—	—	—	—
Oikopleurids damaged	4	—	1272	376	938	355
M. huxleyi	—	—	—	18	188	—
Steg. magnum	—	—	—	—	71	*
Pelagopleura sp.	—	—	—	—	12	—
Frit. haplostoma	—	—	—	71	520	900
Frit. aberrans	—	—	—	*	—	—
Frit. formica	—	—	—	160	88	166
Frit. charybdae	—	—	—	*	—	77
Frit. pellucida	—	—	—	722	56	445
Frit. borealis f. *intermedia*	—	—	60	122	—	107
Frit. borealis f. *sargassi*	—	—	—	6	—	22
Frit. tenella	—	—	—	795	—	296
Frit. venusta	—	—	—	53	—	181
Fritillarians damaged	—	—	—	316	—	67
App. sicula	—	—	189	6	—	*
Numbers of samples	23	9	19	17	24	9

Table 13. Abundance of respective species, *Frequency of Occurrence*×*Mean Percentage*, in surface and vertical hauls in different seasons (Cruises to New Yamato Bank in the Japan Sea, 1950).

3) *Pelagic tunicates of the Japan Sea and the adjacent waters* (Tables 13–18, Text-figs. 11–12).

The largest data about the pelagic tunicates fauna in the Japan Sea are found in TOKIOKA's paper (1951 b) dealing with the material got during the cruises to the New Yamato Bank. Here occurred 22 forms of appendicularians, of which *O. dioica* was the commonest form in Maizuru Bay (Table 14), while *O. longicauda*

	April 26–28		July 25		September 25–27	
	Surface hauls	Vertical haul	Surface hauls	Vertical haul	Surface hauls	Vertical haul
O. longicauda	—	—	2750	—	1876	1700
O. fusiformis	—	—	1742	—	1089	*
O. dioica	10000	10000	5146	10000	462	2100
O. rufescens	—	—	—	—	425	—
Oikopleurids damaged	—	—	363	—	170	—
Frit. haplostoma	—	—	—	—	5976	6200
Number of samples	2	1	6	1	6	1

Table 14. Abundance of respective species, *Frequency of Occurrence*×*Mean Percentage*, in surface and vertical hauls in Maizuru Bay 1950.

	April 26–28				July 25				September 25–27			
	Surface hauls		Vertical hauls		Surface hauls		Vertical hauls		Surface hauls		Vertical hauls	
Number of samples	25		9		25		18		29		10	
0/0	4		1		3		2		1		—	
0.00	21		8		—		1		9		—	
<0.10	—	21	—	8	—	5	8	16	1	24	4	10
0.11– 0.50	—		—		3		7		9		6	
0.51– 1.00	—		—		2		—		5		—	
1.01– 2.00	—		—		2		—		2		—	
2.01– 5.00	—		—		4		—		1		—	
5.01–10.00	—	0	—	0	2	17	—	0	—	4	—	0
>10.01	—		—		—		—		—		—	
∞	—		—		9		—		1		—	

Table 15. Occurrence of respective values of F/L in samples collected during the cruises to New Yamato Bank 1950.

was the commonest one in the open sea (Table 13). During the warm season, July and September, when the Tusima Current, a branch of the Kurosio, was very vigorous along the Japan Sea coast of Honsyû Island, considerable numbers of *O. fusiformis* and *O. rufescens* occurred there, besides pretty many *Frit. haplostoma*, *Frit. pellucida* and *Frit. tenella*. *M. huxleyi* was found, too. While in the cold season, in April, when the Tusima Current was not so strong, the appendicularian fauna was quite simple; only *O. dioica* was prominent and followed by *O. longicauda*. Generally F/L was very low excepting in the very surface layer of the water where *O. fusiformis* predominated over *O. longicauda* sometimes (surface hauls in July), this might be considered as indicating that the warm oceanic water was flowing along the surface (Table 15). Of thaliaceans only *Doliolum nationalis* occurred in significant numbers; *Thalia democratica* was found very rarely.

While I examined chaetognaths of the plankton collection made by the former Husan Fishery Experiment Station in Korea in the waters along the Korean coasts and in the waters extending from the western to southern Kyûsyû, I noted also the occurrences of pelagic tunicates in respective samples. This included the following data shown in Table 16. This seems to show the predominance of *O. longicauda* and frequent occurrences of *O. fusiformis* and *O. rufescens* in these waters, and also the frequent occurrence of *Doliolum nationalis* in the Japan Sea. YAMADA (1933) also showed the common occurrence of *Doliolum nationalis* in the Tyôsen Straits. *O. rufescens* was also found in a plankton sample collected off Yunohama of Yamagata Prefecture on Oct. 16, 1935. Besides the above-mentioned data, many plankton samples were collected by the Synpû-maru of the Kôbe Marine Observatory in this sea and some parts of the 1930 collection were examined to obtain data of pelagic tunicates. Most of samples were collected by vertical hauling from 40, 50 or 60 m to the surface, but some ones were collected by 100–0 m hauling. The results are shown in Table 17. This shows evidently that *O. fusiformis* was extremely scarce at most stations in the sea, although it sometimes increased at some stations in the Tugaru Straits. In a word, *O. longicauda* and *O. dioica* were the remarkable appendicularians found most commonly in the collection; besides, *O. labradoriensis* was found usually in somewhat deeper water. Only *Doliolum nationalis* was met with in examined samples of the present collection. This doliolid seems to be prevailing in the Japan Sea, as IIZUKA & others (1951) and MOTODA & ANRAKU (1951) report the unusual dense population of this species occurred around the southwestern corner of Hokkaidô Island and being extended to the north of Isikari Bay (ca. 44°10′ N×141°04′ E) in the spring to summer of 1950.

Table 16.

	Stations	*Brooksia rostrata*	*Thalia democratica*	*Doliolum denticulatum*	*Doliolum nationalis*	Doliolids Amme	*O. longicauda*	*O. intermedia*	*O. fusiformis*	*O. dioica*	*O. rufescens*	*O. cophocerca*	*O. labradoriensis*	Oikopleurids damaged	*M. huxleyi*	*Frit. haplostoma*	*Frit. pellucida*	*Frit. borealis f. typica*	*Frit. borealis f. sargassi*	*Frit. megachile*	*K. tenuis*
The Japan Sea	4												+					+			
	14						+		+												
	15						C														
	16						C														
	17												+								
	18								+	+											
	19						+		+												
	20			+						+	+										
	21			+	+				+												
	22						+									+					
	23						+							+							
	24						+							+			+			+	
	25		+		+		+		+		+				+						
	27				+		+									+					
	28		+								+										
	29						+		+												
	30				+		+	+	+		+			+	+						
	31				+																
	32	+	*+												+						
The Korean Straits	33		+																		
	34						+														
	36								+		+										
	37				+				+												
	38										+										
	44		*+				+		+						+						

Table 16. (continued)

	Stations	*Brooksia rostrata*	*Thalia democratica*	*Doliolum denticulatum*	*Doliolum nationalis*	Doliolids Amme	*O. longicauda*	*O. intermedia*	*O. fusiformis*	*O. dioica*	*O. rufescens*	*O. cophocerca*	*O. labradoriensis*	Oikopleurids damaged	*M. huxleyi*	*Frit. haplostoma*	*Frit. pellucida*	*Frit. borealis* f. *typica*	*Frit. borealis* f. *sargassi*	*Frit. megachile*	*K. tenuis*
Archipelago along the southern coast of Korea	45						+			+						+			+		+
	47									+											
	51		+			+	+														+
	52															+					
	53								+													
The Yellow Sea	61									+											
	64									+											
of the western coast of Kyûsyû	81																		+		
	82			+				+								+			+		
	83							+													
	87															+	+				
off the southern coast of Kyûsyû	91		+	+																	
	92		+																		
	93		+																		
	94										+										
	95						+														
	96															+					
	97			+																	
	98		+							+											
	100															+					+
	101						+					+									
	102										+										

Occurrences of pelagic tunicates in the plankton samples collected by the former Husan Fishery Experiment Station. C···common, *···var. *orientalis*.

St. 14 (40°35′ N×129°35′ E)···the northern-most locality for *O. longicauda* and *O. fusiformis*, St. 20 (38°15′ N×129°45′ E)···the northern-most locality for *Doliolum deticulatum* and *O. rufescens*, St. 21 (38°15′ N×130°45′ E)···the northern-most locality for *Doliolum nationalis*, St. 22 (38°15′ N×131° 45′ E)···the northern-most locality for *Frit. haplostoma*, St. 24 (37°15′ N×129°45′ E)···the northern-most locality for *Frit. pellucida*, St. 25 (37°15′ N×130°45′ E)···the northern-most locality for *M. huxleyi*. For positions of other stations, see TOKIOKA, T. (1940): The chaetognath fauna of the waters of western Japan. Rec. Oceanogr. Works Japan, Vol. 12, No. 1, pp. 12-22.

	Stations	*Doliolum nationalis*	*O. longicauda*	*O. fusiformis*	*O. dioica*	*O. rufescens*	*O. labradoriensis*	*Frit. formica*	*Frit. borealis* f. *typica*	*Frit. borealis* f. *intermedia*	Fritillarian damaged
The Japan Sea	7		140		11						
	9	2	190	8							
	10–12	1	20	4		5	1		1		1
	13–14		141		39						
	26–27		7				17		3	30	
	36–37						4				
	37		78		5		14				
	56–58		1		9		3				
	64–65		76		14						
	68		65		1		22				
	69		63		7		6				
The Tugaru Straits	72–74		14		13		15				
	75		16		27		16				
	76				6		7				
	79–80		82		27		34				
	94–95	24	32	24	3	2		1			
	94–97		17		3		1				
	98–100	4	53				1				
	101–102		31	23							
	104		4			1					
	105					1					
Mutu Bay	82		92		17		11				
	83		71		3						
	88–89		3				1				
	90						2				

Table 17. Occurrences of pelagic tunicates in the plankton samples collected by the Syunpû-maru 1930.
St. 12 (38°34′ N×128°52′30″ E)···the northern-most locality for *O. fusiformis* and *O. rufescens*, St. 27 (41°14′20″ N×129°48′05″ E)···the northern-most locality for *O. longicauda*; both in the Japan Sea samples.

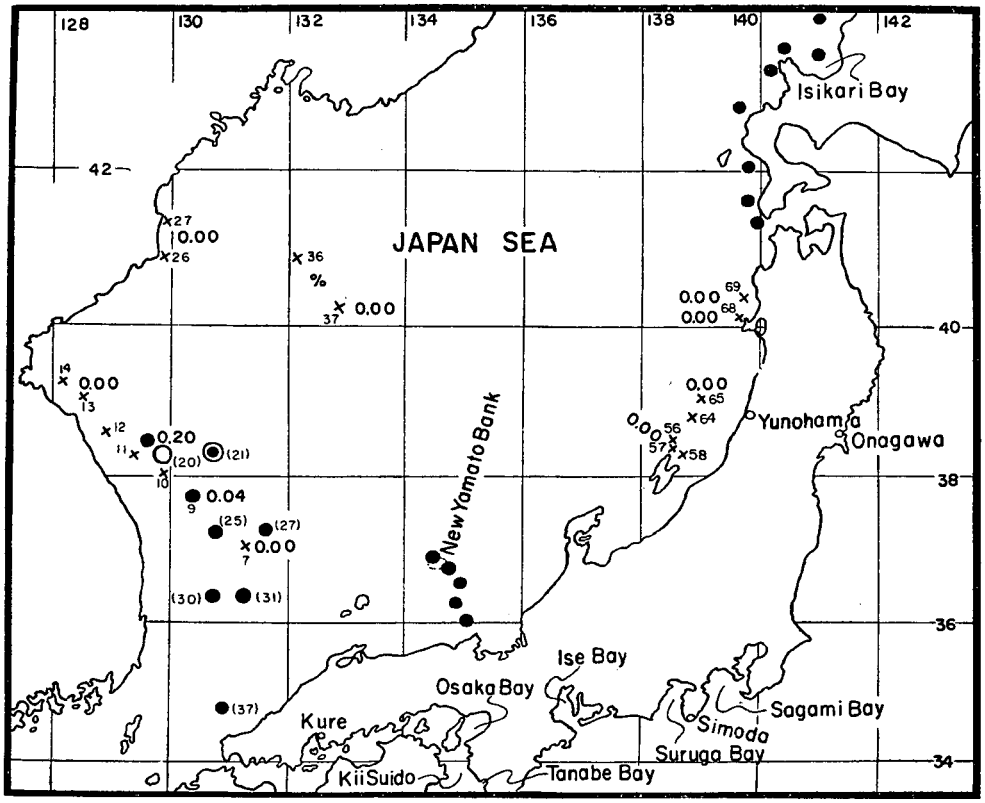

Fig. 11. Distributions of F/L and two doliolids in the Japan Sea. Open circle···*Doliolum denticulatum*, solid circle···*Doliolum nationalis*, large numerals···F/L obtained by the Syunpû-maru, small numerals···station numbers of the Syunpû-maru Expedition 1930, parenthesized small numerals···station numbers of the expedition made by the former Husan Fishery Experiment Station in Korea (TOKIOKA 1940).

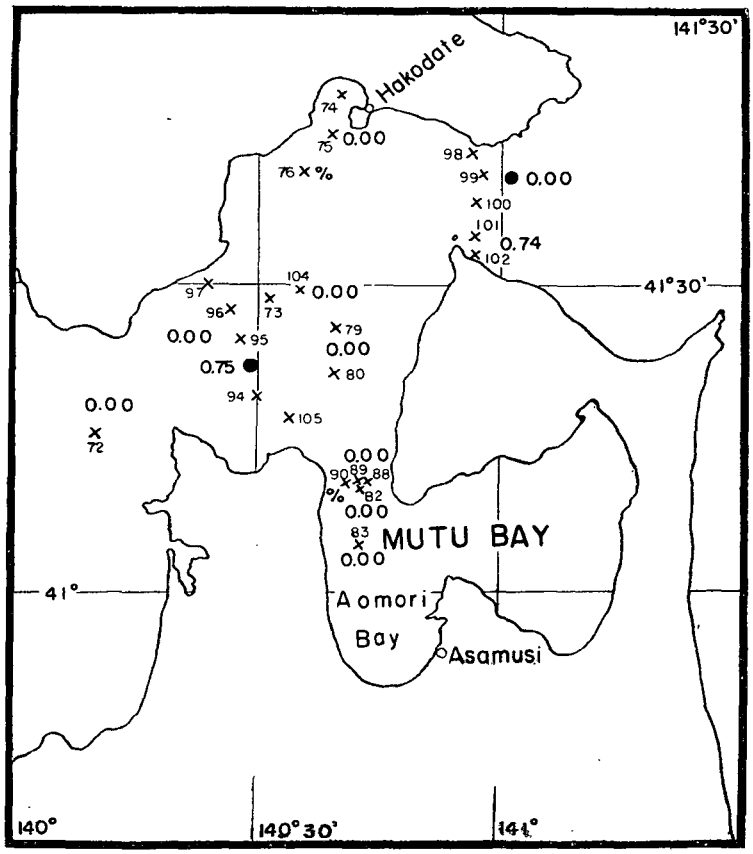

Fig. 12. Distributions of F/L and *Doliolum nationalis* (solid circle) in the Tugaru Straits during the Syunpû-maru Expedition 1930. Large numerals···values of F/L, small numerals···station numbers.

Occurrences of *O. longicauda* and *Doliolum nationalis* in the Tugaru Straits is recognized by KOKUBO (1926), too, on the plankton samples collected June

	August 15, 1930	March 1, 1939
O. longicauda	+	4
O. dioica	+	6
O. labradoriensis	—	45
Frit. borealis f. *typica*	—	5
Fritillaria sp. (damaged)	—	1

Table 18. Appendicularians in Aomori Bay.

21–25, 1924. As to the appendicularian fauna in Aomori Bay, the inner part of Mutu Bay facing the Tugaru Straits, there are the preceding two data. YAMADA (1933) showed the occurrence of *O. dioica* in the Yellow Sea in one of the distribution maps of plankton of that sea. My data in Table 16 show also that this species was the only appendicularian found in the *crassa*-water of the Yellow Sea.

4) *Appendicularian faunas and records of some other pelagic tunicates at various parts of the coasts of Japanese islands* (Tables 19–21).

i—Etorohu Island. Four specimens of *O. longicauda* were found in the plankton sample which was collected by Dr. R. YOSII on Aug. 20, 1933 off Iriribusi (入里節) of this island of the Tisima Islands, a small village facing the Pacific and located about 35 km south to Hitokappu (単冠) Bay.

ii—Hokkaidô Island. The occurrence of *O. dioica* in Lake Notoro (能取) and that of *Oikopleura* sp. (probably *O. dioica*) in Lake Onne-numa (温根沼), both facing the Okhotsk Sea, are reported by Hokkaidô Fishery Experiment Station (1934). The water temperature and chlorinity in these lakes at the time when the samples were collected were:

	Date	Water Temperature	Chlorinity
Notoro	June 1932	11.5–14.6°C	14.490–17.475‰
Onne-numa	Oct. 1932	12.1–13.0°C	15.810–17.600‰

Table 19. Water temperature and chlorinity in the lakes of Hokkaidô Island, where *O. dioica* was collected.

iii—Onagawa (女川) Bay. Two plankton samples from the bay situated on the Pacific coast of the north-eastern part of Honsyû Island were examined and found containing only the following two forms.

	May 19, 1937	Oct. 27, 1939
O. longicauda	40–50	25
O. dioica	3	1

Table 20. Occurrence of appendicularians in Onagawa Bay.

iv—The bays of Sagami and Suruga. Throughout AIDA's paper (1907) dealing with the material collected in or near Misaki Harbour of Sagami Bay and TOKIOKA's material (1940) came from both of Sagami and Suruga bays, seventeen appendicularians have been reported from this area (Table 21). Both *Doliolum denticulatum* and *Doliolum nationalis* are known from this area. SISIDO (1899) recognized the occurrence of *Dolioletta gegenbauri* var. *tritonis* at Misaki in the summer of 1898. Solitary forms of *Thalia democratica* were mostly represented by var. *orientalis* during my stay at the Mitsui Institute of Marine Biology for 1936–1938.

	The Bays of Sagami and Suruga	The vicinity of Seto
O. longicauda	+	+
O. intermedia	+	+
O. fusiformis	+	+
O. fusiformis f. *cornutogastra*	+	+
O. dioica	+	+
O. rufescens	+	+
O. cophocerca	+	+
O. albicans	−	+
M. huxleyi	+	+
Steg. magnum	+	+
Alth. tumida	−	+
Frit. haplostoma	+	+
Frit. formica f. *digitata*	+	+
Frit. fraudax	−	+
Frit. pellucida	+	+
Frit. borealis f. *intermedia*	−	+
Frit. borealis f. *sargassi*	+	+
Frit. megachile	+	+
Frit. tenella	+	−
Frit. venusta	−	+
T. fertilis	+	+
App. sicula	−	+
K. tenuis	+	−
Number of species	17	21

Table 21. Appendicularians occurring in the Bays of Sagami and Suruga and in the vicinity of Seto, Kii.

v—The vicinity of the Seto Marine Biological Laboratory. The laboratory is situated near the end of the peninsula embracing the southern side of Tanabe Bay facing the Kii-Channel. From the vicinity of Seto, where the laboratory is located, twenty-one appendicularians have been reported; two of them, *O. albicans* and *Althoffia tumida*, were collected in the far oceanic water off Cape Sionomisaki. The collections made in the present and preceding regions constituted the most

part of the material on which my general consideration on Japanese appendicularian fauna was based (1955 c), and consequently the relative abundance of respective species are seen in that paper. In an inlet at Yukawa near Katu-ura, situated at a short distance east from Cape Sionomisaki, only *O. dioica* is found commonly. This species is very common in the inner parts of Tanabe Bay, too, where a quantity of *Frit. haplostoma* may join to the population sometimes (TOKIOKA 1940, p. 9). Of thaliaceans occurring in this vicinity, *Dolioletta gegenbauri* var. *tritonis* is the commonest of doliolids, although both *Doliolum denticulatum* and *Doliolum nationalis* occur, too; and *Thalia democratica* and *Salpa fusiformis* are the most frequent visitors of salps.

vi—Ise Bay. I had a chance to examine a plankton sample collected in this bay on March 26, 1938 and found *O. dioica* and *O. fusiformis* in it.

vii—Ôsaka Bay and Kii-Channel. During my observations on chaetognaths and pelagic tunicates in this region (1939), *O. dioica* was prevailing in Ôsaka Bay, besides only a single specimen of *O. longicauda* was found in the collection made in the Bay. On the other hand, *Doliolum nationalis* and *Dolioletta gegenbauri* var. *tritonis* occurred at considerably higher frequencies, namely 53% and 59% respectively, although their occurrences were roughly confined to the western half of the Bay. The ratio F/L was distributed in the Kii-Channel on Nov. 20, 1938 as 0.00 off Yuasa and Kii Yura, 0.03 off Gobô and 0.08 off Minabe, here the localities are arranged in the order from the north adjoining Ôsaka Bay to the south opening to the ocean.

viii—The Inland Sea. *O. dioica* is prevailing in most parts of the Inland Sea. For instance, in each of the six plankton samples collected Aug. 3–6, 1938 in the region stretching from the area off Kure to Hiuti-nada situated nearly at the middle of the Inland Sea, I found a pretty number of *O. dioica*, but *O. longicauda* only in a single sample from the Sound of Ondono-seto. A doliolid Amme was found in a sample collected off Kure, but the specific identification of this Amme was not made.

XII. OCCURRENCE OF PELAGIC TUNICATES IN THE WATERS ADJOINING TO THE NORTH PACIFIC

(Appendix Tables 13–14, Tables 22–27)

1) *Pelagic tunicates of the Siboga area* (Table 22).

IHLE (1908) found fourteen species of appendicularians in 69 plankton samples of the Siboga Expedition. *O. longicauda* was the commonest species and followed by *M. huxleyi* and *O. rufescens*. *O. fusiformis* was much less than *O. longicauda*, occurring at the frequency of only 20%. Among fritillarians, *Frit. pellucida* occurred most frequently, being followed by *Frit. formica* and *Frit. borealis* f. *sargassi*.

Doliolum denticulatum, *Doliolum nationalis* and *Dolioletta gegenbauri* var. *tritonis* were found distributing in the Siboga area (IHLE 1910), and the first and the last

of these three were also recorded near Amboina (BEDOT 1909, p. 168). *Doliolum denticulatum* was quite common in this area and occurred at the frequency of 88%, while other two were rather rare; the frequency of occurrence (F. O.) of *Doliolum nationalis* was only 5% and that of *Dolioletta gegenbauri* var. *tritonis* was

Species	Frequency of Occurrance
Frit. pellucida	25 %
Frit. haplostoma	1.4
Frit. formica	12
Frit. megachile	1.4
Frit. tenella	7
Frit. venusta (described as *Frit. bicornis*)	4
Frit. borealis f. *sargassi* (described as f. *ritteri*)	12
M. huxleyi	64
O. longicauda	84
?*O. intermedia* (described as *O. microstoma*)	1.4
O. fusiformis	20
O. cophocerca	20
O. rufescens	58
Steg. magnum	26

Table 22. Frequency of occurrence of respective species of appendicularians of the Siboga Expedition.

14%. Of the thirteen salps known from this area, *Thalia democratica* was the commonest (F.O.=81%), then followed *Salpa cylindrica* (F. O.=41%), *Salpa fusiformis* including f. *aspera* (F. O.=27%), *Cyclosalpa pinnata* (F. O.=24%), *Ritteriella amboinensis* (F. O.=19%), *Brooksia rostrata* (F. O.−15%) and *Iasis zonaria* (F. O.−11%).

2) *Pelagic tunicates of the Arafura Sea* (Appendix Table 13, Tables 23-24).

As to the appendicularian fauna of this sea, I gave preliminarily a list of species occurred in a small collection made by Mr. S. WADA in 1939 (TOKIOKA 1942); nine species, *O. longicauda, O. intermedia, O. fusiformis, O. fusiformis* f. *cornutogastra, O. dioica, O. rufescens, M. huxleyi, Steg. magnum* and *Frit. borealis* f. *sargassi*, were included in it. *O. longicauda* and *O. rufescens* were the commonest forms and *M. huxleyi* was found rather richly. Later, a comparatively large material collected by Mr. Z. SAGARA in 1955 in the western part of this waters adjoining to the Timor Sea was studied, and results of the examination on this

collection were published in my previous paper of 1956 b in detail. There were nineteen identified species; the abundance of respective species is seen in Table 1 (AR). The most prominent species was *O. longicauda*, next *O. rufescens*, *Frit. borealis* f. *sargassi* (mostly smaller individual) and *O. fusiformis* f. *cornutogastra* and followed by *App. sicula*, *O. dioica* and *O. fusiformis*. *O. fusiformis*

	The Timor Sea	West of 130°E	Between 130°E and 133°E	East of 133°E
O. longicauda	100	100	77	100
O. fusiformis	100	25	7	25
O. fusiformis f. *cornutogastra*	33	94	54	90
O. dioica	17	31	31	50
O. rufescens	83	44	77	70
O. cophocerca	50	38	0	0
M. huxleyi	17	13	0	10
Steg. magnum	17	19	0	5
Frit. haplostoma	50	25	8	15
Frit. formica f. *digitata*	50	0	0	0
Frit. pellucida	17	0	0	0
Frit. borealis f. *sargassi*	100	94	46	85
App. sicula	50	56	46	70
Number of samples	6	16	13	20

Table 23. Frequency of occurrence of respective important species in different sections of the surveyed area in or near the Arafura Sea.

	The Timor Sea		West of 130°E		Between 130°E and 133°E		East of 133°E	
Number of samples	6		16		13		20	
0/0	—		—		3		—	
0.00	—		12		9		15	
< 0.10	1	4	3	16	1	10	4	20
0.11–0.50	2		—		—		1	
0.51–1.00	1		1		—		—	
1.01–2.00	2	2	—	0	—	0	—	0

Table 24. Occurrences of respective values of F/L in different sections of the surveyed area in or near the Arafura Sea.

seemed to trend towards the decrease to the east, this may be seen rather clearly in Table 24 showing the distribution of F/L in respective sections of the surveyed area. *O. cophocerca*, *Frit. formica* f. *digitata* and *Frit. pellucida* were confined to the Timor Sea and its adjoining region during this survey. While, *O. fusiformis* f. *cornutogastra*, *O. dioica* and *App. sicula* seemed to increase towards the eastern part where the neritic character of the water was considered to be stronger than in the western portion. *O. rufescens*, *Frit haplostoma* and *Frit. borealis* f. *sargassi* seemed to be distributed rather evenly.

Of thaliaceans, *Dolioletta gegenbauri* and *Doliolum denticulatum* were the species occurred in significant numbers in this collection; the former was distributed rather evenly in the surveyed area excepting the Timor Sea, while the latter occurred chiefly in the Timor Sea.

3) *Pelagic tunicates in the waters off eastern Australia* (Table 25).

(1) The Great Barrier Reef Region. The pelagic tunicates of the Great Barrier Reef Expedition 1928–29 were identified by HASTINGS (1931) and the occurrence of respective species was studied in detail by RUSSELL and COLMAN (1935). There occurred nine species of Thaliacea and eight of Appendicularia. Of doliolids, *Doliolum denticulatum* was the commonest, the frequency of occurrence of this species throughout 121 samples consisting of oblique hauls of the 1-metre stramin net and those of the coarse silk tow-net was 74%, while other two, *Dolioletta gegenbauri* and its variety *tritonis*, occurred only insignificantly. Among salps, *Thalia democratica* was the commonest one, its frequency of occurrence attained 70% (of 121 samples); other five species were *Cyclosalpa pinnata*, *Brooksia rostrata*, *Iasis zonaria*, *Salpa cylindrica* and *Pegea confoederata*.

In appendicularians, *O. rufescens* was the commonest, its frequency of occurrence was 54% (of 121 samples). *M. huxleyi* occurred very frequently (F. O.—66%), but it was much less than *O. rufescens*. *O. longicauda* was found in 12 of 74 samples (F. O.—16%) and *Steg. magnum* in 29 of 121 samples (F. O.—24%), both in very small numbers. *O. fusiformis*, *Frit. haplostoma*, *Frit. pellucida* and *Frit. borealis* f. *intermedia* occurred only insignificantly. Abundant occurrences of large-sized *Megalocerus* and *Stegosoma* and of *O. rufescens* whose house seems to be tough enough against the towing by a coarse net and contrarily the scarcity of small-sized forms may be safely attributable to the using of coarse stramin or silk nets. HASTINGS (1931) mentions that "the absence of *Oikopleura cophocerca* is rather surprising", but this might be related with the complete absence of this species in the eastern part of the Arafura Sea (Table 23).

(2) South eastern Australian waters (Table 25). The large collection made by the research vessel M. V. Warreen of the Commonwealth Council for Scientific and Industrial Research in the south eastern Australian area, extending from the tropic of Capricorn to part of the South Australian coast, was studied by THOMPSON (1948) in detail. Of two doliolids, *Doliolum denticulatum* (including

D. nationalis) was much more abundant than *Dolioletta gegenbauri* (including var. *tritonis*), though the distribution of the latter extended more to the south. HERDMAN (1888) reported the occurrence of *Doliolum denticulatum* in the Bass Straits, but this is a questionable record. Of 18 salps, *Thalia democratica* was the commonest. *Ihlea magalhanica* and *Salpa fusiformis* were abundant in the southern half of the surveyed area, *Traustedtia multitentaculata*, *Brooksia rostrata*, *Salpa maxima*, *Salpa cylindrica*, *Iasis zonaria* and *Pegea confoederata* occurred fairy abundantly in the order of this listing.

Of 22 species of appendicularians, *O. longicauda* was the outstanding species and other important species were *O. fusiformis*, *Frit. pellucida* and *O. rufescens*.

O. longicauda	269,912
O. fusiformis	57,485
Frit. pellucida	46,654
O. rufescens	45,718
O. dioica	15,159
M. huxleyi	11,294
Steg. magnum	9,751
O. albicans	8,897
O. cophocerca	3,597
O. cornutogastra	3,483
Frit. formica	1,580
O. parva	1,536
O. intermedia	1,263
Frit. borealis f. *sargassi*	815
Frit. haplostoma	300

Table 25. Total individuals of respective fifteen important species of appendicularians occurring in south-eastern Australian waters. (THOMPSON 1948)

Totals of individuals of respective fifteen species occurred in the surveyed area in significant numbers are quoted here from THOMPSON's book (p. 166). Relatively large population of *O. dioica* and low value of F/L (0.21) seem to show that the above totals obtained throughout the whole collection might be strongly influenced by relatively frequent hauls made in the coastal waters. Small populations of *Frit. borealis* f. *sargassi* and *Frit. haplostoma* are rather impressive when these are compared with those in the adjacent waters such as the Arafura Sea and the Marshall Islands area surveyed by the Syunkotu-maru. The complete absence of *App. sicula* in this area is quite strange.

4) *Pelagic tunicates of the South Pacific.*

In addition to several appendicularians commonly occurring in the warm waters of the world oceans, LOHMANN (1931) identified the following 15 species

in the collection made by FRIEDRICH DAHL in 1896–97 at Ralum of the Bismarck Archipelago, approximately 4° S×152° E.

O. gracilis
O. graciloides
O. parva
O. mediterranea
P. verticalis
P. gracilis
Alth. tumida
Frit. fraudax
Frit. gracilis
Frit. borealis f. *intermedia* (described as *Frit. messanensis* by LOHMANN)
Frit. borealis f. *sargassi* (described as *Frit. borealis truncata* by LOHMANN)
Frit. tenella
Frit. venusta (described as *Frit. bicornis* by LOHMANN)
T. fertilis
App. sicula

GARSTANG and GEORGESON (1935) recorded *O. longicauda*, *O. rufescens*, *O. dioica* and *Steg. magnum* (described as a new species *Stegosoma conogaster*) from the vicinity of Three Kings Islands of Northern New Zealand during the British Antarctic ("Terra Nova") Expedition, 1910. There, the first of the four species was the commonest and the last one was represented by 76 individuals, while the second and the third were quite scarce. Recently BARY (1960) studied the plankton samples collected by H.M.N.Z.S. Lachlau in south-eastern New Zealand waters stretching from 43°15′S to 51°41′S and published that *O. fusiformis* was captured by the hauls made mainly in cooler oceanic waters and *O. dioica* occurred infrequently in warm coastal waters. Lastly TOKIOKA (1960) records *Frit. borealis* f. *sargassi*, *O. longicauda*, *O. dioica*, *O. fusiformis*, *O. parva* and *Steg. magnum* from the lagoon water near Noumea, New Caledonia; these species are listed here in the order of abundance.

Of Thaliacea, GARSTANG (1933) recorded *Dolioletta gegenbauri*, *Doliolum denticulatum* and lesser individuals of *Doliolina mülleri* and *Dolioletta mirabilis* at the South Pacific stations during the British Antarctic Expedition and recently THOMPSON (1954) recorded *Pyrosoma atlanticum* and *Iasis* at the stations near Tasmania during the B.A.N.Z. Antarctic Research Expedition 1929–31 and also *Thetys* and *Salpa fusiformis* in the area, these two species were considered by him to tolerate cooler conditions. Especially *S. fusiformis* appears to be most tolerant, of all salp species, of very cold water condition, its distribution being extended even to the pack ice area at 65° S. BARY (1960) records abundant occurrences of *Dolioletta valdiviae* together with its old oozooids and *Pyrosoma atlanticum* in the area he studied. There, *Ihlea magalhanica* APSTEIN was very

common, *Salpa fusiformis* f. *aspera* was common and *Thalia democratica* occurred abundantly though infrequently; besides, *Pyrosoma spinosum*, *Iasis zonaria* and *Pegea confoederata* were recorded. *Thalia democratica* is described in his paper without being divided into f. *typica* and var. *orientalis*. TOKIOKA (1960) records *Thalia democratica* var. *orientalis* and *Dolioletta gegenbauri* var. *tritonis* in the south-western coastal waters of New Caledonia.

5) *Pelagic tunicates of the Indian Ocean* (Appendix Table 14, Tables 26–27).

The appendicularian fauna of the Indian Ocean has not yet been studied so fully as to be exactly compared with those of the Atlantic and some parts of the Pacific. First the fauna of the Indian Ocean was introduced to us by the "Deutsche Südpolar-Expedition" and the "Tiefsee-Expedition". In addition to the species listed in the column of CI of Table 1, *Chunopleura microgaster* LOHMANN 1914 a and *Frit. venusta* (recorded as *F. bicornis*) were captured by the last Expedition near Sumatra. Generally speaking, appendicularians were very abundant in the northern tropical part of the Indian Ocean, especially they were found in very dense populations along the equatorial East African coast and at the entrance to Aden Bay under the special condition effected by monsoon; while they were extremely scarce in the southern part of the Indian Ocean (LOHMANN 1933, p. 176), although some warm water appendicularian population consisting of *O. longicauda*, *O. fusiformis* and *Frit. borealis* f. *sargassi* was found extending to the "Tiefsee-Expedition" Station 43°44′ S×75°33.7′ E where the water temperature was only 8.8°C. Numbers of individuals caught in the southern Indian Ocean during the "Südpolar-Expedition" (p. 204) were:

O. longicauda	315	*Frit. haplostoma*	4
Steg. magnum	246	*Frit. tenella*	4
O. fusiformis	58	*Frit. pellucida*	3
O. cophocerca	22	*Frit. formica*	2
O. albicans	11	*O. parva*	1.
O. rufescens	9		

The occurrence of *O. fusiformis* f. *cornutogastra* along the Somalian coast and at Poat Natal is considered to be noted. Later, SEWELL (1953) recorded a single individual of each of *Frit. pellucida* and *Frit. formica* and several specimens of *O. dioica* and *O. rufescens* from Sta. 58 (22°22′12″ N×59°57′30″ E) in the Arabian Sea region, where "enormous numbers of *Noctiluca* were swarming in the surface water". It is noteworthy that none of *O. longicauda* nor *O. fusiformis* occurred there. TOKIOKA (1956 a) shows the occurrence of 23 forms in the central part of the Indian Ocean (Table 1, CI). The commonest species was *O. longicauda* and next *O. fusiformis*. *O. rufescens* and *Steg. magnum* occurred abundantly, too. *O. cophocerca* and *Frit. borealis* f. *sargassi* were met with frequently, but less than the preceding four species. In addition to them, *O. albicans*, *O. parva*, *O. dioica*, *Frit. pellucida*, *Frit. haplostoma* and *Frit. formica* f.

digitata occurred in significant numbers. The remarkable scarcity of *M. huxleyi* is rather strange when it is compared with the abundance of *Steg. magnum* in this region. F/L was less than 1.00 in all 26 samples. The same author (1955 b) found 12 species in the collections made in the North Eastern part of the Ocean (Nicobar, Nias and Bali-Lombok). These include the first six of abundant species in the central part; besides, *O. gracilis*, *M. huxleyi*, *Frit. haplostoma*, *Frit. formica*, *Frit. pellucida* and *Frit. venusta*. The last one was not included in the collection from the central part.

0.00	5	26
<0.10	3	
0.11–0.50	12	
0.51–1.00	6	
>1.01	0	0
Number of samples	26	

Table 26. F/L in the central part of the Indian Ocean (TOKIOKA 1956a).

In Lawson's Bay near Waltair, East India, according to GANAPATI and BHAVANARAYAMA (1958), *O. longicauda*, *O. fusiformis* and *O. dioica* are found throughout the year and considered to be able to tolerate wide ranges of salinity and temperature. *Frit. lucibila* (=*Frit. haplostoma*), *Frit. campila* (=probably *haplostoma* with a slightly wider tail musculature), *Frit. formica*, *O. cophocerca* and some salps (*Pegea*, *Ritteriella amboinensis*, *Cyclosalpa pinnata* and *Salpa cylindrica*) are found in the southerly current, characterized by low salinity, high turbidity and high temperature, during July~December, while *Frit. haplostoma*, *Frit. limpida* (=*haplostoma*), *Frit. pellucida*, *Frit. borealis* f. *sargassi*, *O. rufescens* and *Althoffia pacifica* (=probably *Pelagopleura gracilis*) occur in the northerly current, characterized by high salinity, high transparency and low temperature, during January~June. In addition to these, "in the March~April period, there is upwelling in the nearshore waters and the mesopelagic *Frit. pellucida* makes its appearance in the surface waters during these months". It is rather difficult to find out differences of any essential significance between the community including *Frit. haplostoma*, *Frit. formica*, *O. cophocerca* and some salps and that containing *Frit. haplostoma*, *Frit. pellucida*, *Frit. borealis* f. *sargassi*, *O. rufescens* and *Pelagopleura*. But this seems to show that the composition of far offshore appendicularian populations may differ considerably from time to time and that *Frit. haplostoma* occurs rather commonly in this region. As fragmental records, OKA (1915) identified *Megalocercus* sp. (most probably *M. huxleyi*) together with salpas, *Iasis*, *Metcalfina*, *Salpa cylindrica*, *Thetys* and *Pegea*, in the collection of the Indian Museum.

On the west coast of Australia, LOHMANN (1909 a) examined nine plankton samples collected in or near Sharks Bay. In six hauls made in the Bay only *O. dioica* was found, while in three others collected near Fremantle outside the Bay *O. longicauda*, *O. fusiformis*, *O. rufescens* and *O. cophocerca* occurred in addition to *O. dioica*; proportions of these five species are given below in Table 27. F/L was 0.05–0.09 in these hauls. In addition to the above-mentioned five oiko-

pleurids, a single specimen of *Fritillaria abjornseni* was found at North Fremantle in the Swan River (sea water) and three individuals of *Doliolum denticulatum* occurred in the hauls made in Sharks Bay.

Of Thaliacea, besides the previously made records by SEWELL (1926) and others, SEWELL (1953) records that *Thalia* was the commonest of all salpas and *Doliolum denticulatum* and *Dolioletta gegenbauri* occurred abundantly in the surveyed Arabian Sea region during the John Murray Expedition 1933–34; here *Doliolum nationalis* was included in the former and *Dolioletta gegenbauri* var. *tritonis* was treated under the latter species. He mentions that *Thalia democratica* var. *orientalis* occurred in the area, too and there it seemed to be more abundant in the greater depths than in the surface water at least at Station 61. My examination on the collection from the central part of this ocean revealed that *Doliolum nationalis* occurred in the collection, but none of *Doliolum denticulatum* (Appendix

	Station 24	Stations 28 and 28a near the Bay
O. longicauda	89.5 %	43.5 %
O. fusiformis	8.5	2.0
O. dioica	0.25	38.5
O. rufescens	1.5	16.0
O. cophocerca	0.25	—
Number of individuals	348	169

Table 27. Proportions of five speciess of appendicularians occurred near Sharks Bay. (LOHMANN 1909a)

Table 14). According to the results of the "Tiefsee-Expedition" by the "Valdivia" (NEUMANN 1906), *Doliolum denticulatum* was found widely distributed in the warm-water regions of the Indian Ocean, while *Doliolum nationalis* occurred in the Gulf of Bengal, in the waters along Sumatra and the eastern coast of Africa extending from Aden to Cape Town; besides, the occurrences near the Seychells and St. Paul Island were recorded, the occurrence at the latter locality must be noted as it is located near the middle of the southern Indian Ocean far apart from the coastal waters. The distributions of *Dolioletta gegenbauri* and its variety *tritonis* seemed to conform roughly to that of *Doliolum nationalis*, although the distribution of the first form was extended to the area beyond Madagascar and to New Amsterdam. In the Red Sea, are recorded the occurrence of *Doliolum denticulatum*, *Doliolum nationalis* and *Doliolina intermedia*. The most important salps collected during the expedition of the "Investigator" 1922–23 were *Thalia democratica*, *Salpa cylindrica* and *Iasis zonaria* (SEWELL 1926, p. 117).

XIII. PELAGIC TUNICATES OF THE ATLANTIC

(a) *The Atlantic Ocean.* Appendicularians:—The first report on the appendicularian fauna of the warm water regions of the Atlantic was given by LANGERHANS (1880) who recorded nine species from the waters surrounding the Madeiras, they were *O. longicauda* (described as *O. velifera*), *O. fusiformis*, *O. dioica*, *O. rufescens*, *Steg. magnum* (described as *Oikopleura magna*), *Frit. formica*, *Frit. pellucida* (listed as *Frit. furcata*), *Frit. megachile* and *App. sicula.* The fauna of the North Atlantic was then clarified by LOHMANN's comprehensive studies (1896 b) based on the material of the Plankton Expedition. This time were identified the 25 species shown in Table 28. Then the collections of the "Tiefsee-Expedition" (1898) and the "Deutsche Südpolar-Expedition" (1901–03) were examined by the same author and others and the following eleven species: *O. graciloides*, *O. fusiformis* f. *cornutogastra*, *M. abyssorum* (described by LOHMANN as *M. atlanticus* LOHMANN 1914), *P. verticalis*, *P. oppressa* (LOMANN) 1914, *P. gracilis*, *Bathochordaeus charon*, *Frit. helenae* LOHMANN 1924, *Frit. drygalski* LOHMANN 1924, *Frit. borealis* f. *intermedia* (described by LOHMANN as *Frit. messanensis*) and *Frit. scillae* were added to the warm water appendicularian fauna of the Atlantic. The occurrence of *Frit. megachile* in the Madeiras waters was doubted by LOHMANN, as the specimen described by LANGERHANS resembled LOHMANN's *Frit. tenella.* Recently, however, this species was reported again from the South Atlantic by BJÖRNBERG & FORNERIS (1955) who recorded 15 species of appendicularians from the surrounding waters of Trinidad Island (20°30′ S×29°22′ W) and Jaseur Bank (20°40′ S×35°10′ W), this includes the new record of *Frit. abjornseni* in the Atlantic. BERNARD (1958) expresses her opinion that *Frit. drygalski* might be identical with *Frit. aequatorialis* (p. 216). Treating this as a distinct one, in all 38 forms of appendicularians are known from the warm waters of the Atlantic.

In the warm water regions of the Atlantic, appendicularians are most abundant in the equatorial region and the starting area of the North Equatorial Current along the western African coast near the Cape Verde Islands and the wide area along the Brazilian coast near the estuary of the Amazon. On the other hand, in the West Wind Drift in the north-eastern part of the North Atlantic, appendicularians are very poor both in number of individuals and number of occurring species.

O. longicauda is the commonest species throughout the warm water regions of the Atlantic. Next *O. fusiformis* which is also distributed widely, *O. rufescens* and *O. cophocerca* occur abundantly, especially in the far offshore waters, and may take the place of *O. fusiformis* in some areas such as the western half of the Sargasso Sea, the northern part of the starting area of the North Equatorial Current and the Benguela Stream. Frequent and abundant occurrence of *O. dioica* is a remarkable feature characteristic of the waters near the coast and also the currents strongly influenced by the coastal water as in the Guinea Current. The

A	Florida Current	Sargasso Sea	North Equa. Current	Guinea Current	South Equa. Current (Mix. Ar.)	South Equa. Current	West-wind Drift	Sum
O. longicauda	*1120	*2726	4700	4900	*3510	*5518	*2500	24974
O. intermedia	*	*117	297	38	30	—	13	495
O. fusiformis	140	528	1000	1232	720	855	300	4775
O. gracilis	—	38	—	—	—	—	—	38
O. cophocerca	*560	*1675	913	825	*770	*158	3800	8701
O. albicans	—	*45.6	*	*50	*39	*	*	135
O. parva	*	*153	—	143	—	—	—	296
O. rufescens	180	1170	2380	1210	*792	*568	413	6713
O. dioica	—	**351	637	1437	80	163	25	2693

B	Frequency of Occurrence							Mean
Steg. magnum	20	82	50	75	60	32	50	53
Folia gracilis	—	—	—	38	10	—	—	7
Alth. tumida	20	27	—	—	20	—	—	10
T. fertilis	20	18	33	13	—	—	—	12
Frit. gracilis	—	27	—	38	10	11	—	12
Frit. pellucida	40	58	83	38	40	32	50	49
Frit. fraudax	—	18	—	—	—	—	—	3
Frit. aberrans	—	—	—	—	10	—	—	1
Frit. haplostoma	20	30	67	50	—	32	—	28
Frit. formica	40	82	67	88	50	63	50	63
Frit. aequatorialis	—	—	—	—	20	16	—	5
Frit. tenella	20	27	33	38	10	16	—	21
Frit. venusta	40	6	50	63	50	11	—	31
Frit. borealis f. *sargassi*	40	42	67	63	40	42	25	46
App. sicula	20	70	67	88	60	63	50	60
K. tenuis	—	15	17	—	—	—	—	5
Nomber of samples	5	33	6	8	10	19	4	

Table 28. Abundance of warm water-oikopleurids, *Frequency of Occurrence*×*Mean Percentage*, in respective currents and seas during the Plankton Expedition (A), and Frequency of Occurrence of other appendicularians in the same areas (B). *···excluding the occurrences not shown in numbers, **···including the 100% occurrence at St. George Harbour, Bermuda on August 10. Equa.···Equatorial, Mix. Ar.···Mixing area. (LOHMANN 1896b)

C

O. longicauda	77.5%
O. intermedia	1.0
O. fusiformis	3.5
O. rufescens	1.0
O. cophocerca	4.0
O. albicans	7.0

Table 28 (C). Percentage composition of the appendicularian-population in the Benguela Stream in the range between Ascension and Cape Town 1901–1903.
(LOHMANN & BÜCKMANN 1926, pp. 196–197)

distribution of F/L during the Plankton Expedition seems to show the trend towards the slight increase in the equatorial region (Table 29). BJÖRNBERG and FORNERIS (1956 a) show a very interesting F/L distribution around Fernando de Noronha Island. Values of F/L were generally higher at the stations located on the northern side of the island than at the south side stations, although it is difficult to judge whether or not the above distribution of F/L values is attributable to different water masses flowing along respective sides of the island. In the North Atlantic, the dominancy of *O. longicauda* becomes indistinct with the fall of the water temperature, contrarily percentages of *O. fusiformis*, *O. cophocerca* and *O. albicans* are raised till *O. longicauda* disappears at last and the dominancy is taken by *O. fusiformis* which may reach near Greenland (LOHMANN 1896 a). In a sample collected at the station of Aug. 2a in the mixing area between the warm Florida Current and the cold Labrador Current during the Plankton Expedition, many *O. dioica* and some *O. parva* and *O. albicans* were found in addition to cold water species *O. labradoriensis* and *Frit. borealis* f. *typica*, but none of *O. longicauda* was found. The distribution of *O. fusiformis* is very wide near the equatorial region and in the northern area beyond the region, but it seems to be narrowed in the South Atlantic south of ca. 10° S, there the distribution is seen along the continents, although the edge of the dense distribution attains 50° S; while the southern limit of dense occurrences of *O. longicauda* is seen along the isotherm of 18°C and the distribution seems to be limited by the 15°C isotherm (LOHMANN & HENTSCHEL 1939). UDVARDY (1958) records that *O. longicauda* occurred during the Swedish Antarctic Expedition 1901–03 most commonly between 38°50′ N—43°52′ S and its dense population was observed at 51°14′ S, while *O. fusiformis* was found between 35°5′ N—61°29′ S. These seem to approve that *O. fusiformis* is more tolerant against the lowered water temperature than *O. longicauda*. Then,

it is very strange that *O. longicauda* had been found in the Antarctic Sea, reaching 72°30′ S, while *O. fusiformis* had never been collected in the Antarctic (LOHMANN 1928). Of fritillarians, *Frit. formica*, *Frit. pellucida* and *Frit. borealis* f. *sargassi* are the commonent species, *Frit. formica* occurred most frequently during the Plankton Expedition, but *Frit. borealis* (chiefly f. *sargassi*) was the most abundant of all fritillarians and at the same time of all appendicularians in the 50–0 m plankton samples collected near Fernando de Noronha Island (ca. 3°41′ S×

A	Florida Current		Sargasso Sea		North Equatorial Current		Guinea Current		South Equatorial Mixing Area		South Equatorial Current		West Wind Drift	
Number of samples	5		33		6		8		10		19		4	
0/0	1		3		—		—		—		1		—	
v/v	—		2		—		—		2		3		1	
0.00	3	3	15	18	—	2	1	1	2	3	—	5	1	2
<0.10	—		3		2		—		1		5		1	
0.11–0.50	1	1	8	10	3	4	7	7	3	4	8	9	—	1
0.51–1.00	—		2		1		—		1		1		1	
∞	—		—		—		—		1		1		—	

B	North side of the island		South side of the island	
Number of stations	4		5	
Number of samples	5		12	
<0.10	1	1	—	12
0.11–0.50	—		7	
0.51–1.00	—		5	
1.01–2.00	4	4	—	0

C		
0.00	2	8
<0.10	1	
0.11–0.50	3	
0.51–1.00	2	
1.01–2.00	1	1
Number of samples	9	

Table 29. Occurrences of respective values of F/L in the Atlantic. A···In the collection of the Plankton Expedition (LOHMANN 1896b), B···In the collection made near Fernando de Noronha Island, the maximum value 1.87 (BJÖRNBERG & FORNERIS 1956a); C···IIn the collection made near Alcatrazes Island, the maximum value 1.43. (BJÖRNBERG & FORNERIS 1956b)

32°25′ W) in the South Equatorial Current and *Frit. pellucida* was the next one (BJÖRNBERG & FORNERIS 1956 a) and *Frit. pellucida* was the most significant fritillarian in the collection made near Alcatrazes Island located approximately at 24° S×46° W (BJÖRNBERG & FORNERIS 1956 b).

Frit. haplostoma usually occurs sparsely in the far offshore waters of the Atlantic, although it was found occurring in swarms at some coastal stations such

as the station of Oct. 9 during the Plankton Expeditipn not far from the Tocantin Delta near the estuary of the Amazon (LOHMANN 1896 b) and at St. 10, an inshore station in the surrounding waters of Alcatrazes Island (BJÖRNBERG & FORNERIS 1956 b). Results of the German Atlantic Expedition by the "Meteor" 1925–27 show also that pretty abundant occurrences of this species were observed along the eastern coast of South America, in the range between La Plata and Rio and off Cape S. Roque, and near the estuary of the Niger (LOHMANN & HENTSCHEL 1939).

Appendicularian faunas of the Baltic Sea and the North Sea are represented by *O. dioica* and *Frit. borealis*; that of the latter sea is enriched by frequent visiting of *O. fusiformis* and *O. labradoriensis*; besides, there are records of rare occurrences of *O. vanhöffeni*, *Frit. venusta* and *App. sicula* (BÜCKMANN 1926, also BERRILL 1950). *Frit. borealis* is mostly represented by f. *typica*, although f. *intermedia* can be seen sometimes.

In the inlet waters or the very coastal water in the warm water regions of the Atlantic, *O. dioia* and *O. longicauda* are common inhabitants, they were ever found even in the somewhat brackish water near the Tocantin Delta, especially *O. dioica* was found in the Rio Tocantin upper than Para during the Plankton Expedition.

Thaliaceans:—Many papers have been published on the Atlantic salps and it is a well-known fact that *Thalia democratica* is the commonest one in the warm water regions, although the distinction between the typical and *orientalis* forms have never been made and consequently the occurrence of var. *orientalis* in the Atlantic can not yet be recognized.

During the Plankton Expedition, *Doliolum denticulatum* was distributed very widely in the warm water regions, although its distributional area seemed to be narrower than that of *Doliolum nationalis* in the north-eastern part of the North Atlantic (BORGERT 1894). The distribution of *Doliolum nationalis* is, however, considered to show the trend towards the increase in the inshore waters, for instance during the Plankton Expedition this doliolum occurred infrequently at offshore stations in the Florida Current, Sargasso Sea and North Equatorial Current, but was collected abundantly near the Cape Verde Islands and at most stations in the North Equatorial Current, Guinea Current and South Equatorial Current located in the range between Cape Verde and Ascension, excepting only a single station. It was very scarce again at offshore stations in the South Equatorial Current, located in the range between Ascension and Fernando de Noronha, but it occurred at every station in the same current in the range between Fernando de Noronha and the estuary of the Rio Para. Also it was found in large numbers at the station of Oct. 30 off Spain and near the western end of the English Channel and the entrance to the Mediterranean Sea. Occurrences of *Doliolum nationalis* off Plymouth are reported also by RUSSELL and HASTINGS (1933).

In the South Atlantic, *Doliolum denticulatum* occurs steadily in the waters off the west coast of Africa extending from the equatorial zone to the Benguela Current, but *Doliolum nationalis* had been found occurring abundantly only in the equatorial zone, stopping suddenly and completely when the cool waters of the Benguela Stream were encountered (NEUMANN 1906). *Doliolum nationalis* was not found in the Benguela Stream during the German Atlantic Expedition by the "Meteor", either (KRÜGER 1939). Recently, however, ZYL (1960) records the occurrence of this species in the routine area in the Benguela Stream off South Africa and on many occasions in association with *Doliolum denticulatum*. There, *Doliolum denticulatum* and many salps show their highest frequencies of occurrences in the spring~summer season, but *Doliolum nationalis* solely has its highest incidence during winter. Furthermore these is a direct relationship between the mean integral temperature of the water of the 0–50 m layer and the occurrences of many salps and *Doliolum denticulatum* in quantities, but the relation between the former and the dense occurrence of *Doliolum nationalis* is inverse. Thus the distribution of *Doliolum denticulatum* and that of *Doliolum nationalis* show the tendency of having inverse relations in the Atlantic. The "Tiefsee-Expedition" caught some *Doliolum denticulatum* and *Doliolum nationalis* near Cape Town (NEUMANN 1906), these were very probably carried there by the Agulhas Current.

The distribution of *Dolioletta gegenbauri* var. *tritonis* seems to resemble somewhat that of *Doliolum nationalis*, although it extends more northerly than that of *Doliolum nationalis*. During the Plankton Expedition, this doliolum occurred most abundantly in the eastern parts of the North Equatorial, Guinea and South Equatorial Currents, stretching between the Cape Verde Islands and Ascension and also in the western part of the South Equatorial Current between Fernando de Noronha Island and the estuary of the Rio Para. In addition, it occurred near the boundary between the Florida Stream and the Sargasso Sea and was found carried north by the Gulf Stream to New Foundland in west and to the Hebrides in east (BORGERT 1894). In the southern South Atlantic it occurs around the Cape of Good Hope and in the Benguela Gurrent where it is found most frequently in spring~summer, though rather rare (ZYL 1960). *Dolioletta gegenbauri* is recorded from the waters near the Shetlands, Faeroes and Scottish waters (FRASER 1949) and also from the North Sea and occasionally from the western portion of the English Channel (RUSSELL and HASTINGS 1933); most specimens belong to the typical form, but a small part is represented by var. *tritonis*. It occurs more abundantly in the Mediterranean Sea than in the Sargasso Sea.

Doliolina intermedia reaches northerly 63,3° N in the northern mixing area, but its abundant occurrence seems to be confined to the subtropical zone of the South Atlantic, south of 15° S in the eastern and of 30° S in the western part of the ocean, namely the distribution is limited northerly by the line of the tropical convergence (KRÜGER 1939).

(b) *The Mediterranean Sea.* FOL (1872, 1874) recorded the following twelve appendicularians from the waters around Messiana:

O. longicauda (described as *O. spissa*)
O. fusiformis
O. dioica
O. rufescens
O. cophocerca
Frit. haplostoma (described as *Frit. aplostoma*)
Frit. formica
Frit. urticans
Frit. pellucida (described as *Frit. furcata*)
Frit. megachile
App. sicula
K. tenuis

The appendicularian fauna at Messina, however, had grown up to be 28 species when LOHMANN listed them in 1909 b.

O. longicauda	*Frit. formica*
O. intermedia	*Frit. fraudax*
O. fusiformis	*Frit. gracilis*
O. gracilis	*Frit. aequatorialis*
O. dioica	*Frit. urticans*
O. rufescens	*Frit. pellucida*
O. parva	*Frit. borealis*
O. mediterranea Lohmann 1899	*Frit. messanensis*
O. cophocerca	*Frit. megachile*
O. albicans	*Frit. tenella*
M. abyssorum	*Frit. venusta*
Steg. magnum	*App. sicula*
Folia gracilis	*K. tenuis*
Frit. haplostoma	*K. mossi* Herdman

Of these species, *Frit. borealis* probably means *Frit. borealis* f. *intermedia* and partly f. *sargassi*, *Frit. messanensis* is considered to be identical with *Frit. borealis* f. *intermedia* as mentioned already on P. 363 and *K. mossi* may be treated as a synonym of *K. tenuis*. In addition to the above 27 forms, *O. graciloides*, *Frit. charybdae*, *Frit. scillae* LOHMANN 1898 and *K. oceanica* LOHMANN 1899 had been known from the neighbouring waters of Messina. Thus, the fauna have increased to 31 forms; among these *O. longicauda*, *O. cophocerca*, *Frit. pellucida* and *Frit. borealis* are remarkable. In 1913, UEBEL reported *O. najadis* from the Adriatic Sea, but this is considered to be a form of *O. parva*, having a comparatively wider tail musculature. *Frit. formica* described from the Mediterranean Sea was

represented by f. *tuberculata* which was defined by LOHMANN & BÜCKMANN (1926).

VERNIÈRES (1933) reports eleven appendicularians from Banyuls, six from Sète and fifteen from Villefranche (1933 and 34). His *Fritillaria borealis acuta* f. *typica* var. *mediterranea* from Banyuls may be treated as belonging to *Frit. borealis* f. *intermedia* as mentioned already on page 363 and his *Frit. borealis troncata elongata* from Villefranche may be considered to be included also in *Frit. borealis* f.

	Banyuls	Sète	Villefranche
O. longicauda	+	+	+
O. intermedia	−	−	+
O. fusiformis	+	+	+
O. dioica	+	+	+
O. parva	+	−	−
O. cophocerca	+	−	+
O. albicans	+	+	+
Steg. magnum	−	−	+
Pelagopleura haranti	−	−	+
Frit. haplostoma	+	−	−
Frit. formica	+	+	+
Frit. gracilis	−	−	+
Frit. pellucida	+	+	+
Frit. borealis f. *intermedia*	+	−	+
Frit. megachile	−	−	+
Frit. scillae	−	−	+
T. fertilis	−	−	+
K. tenuis	+	−	+

Table 30. Occurrences of appendicularians along the Mediterranean coast of France.

intermedia. *O. longicauda* was the commonest species, *O. fusiformis* and *Frit. pellucida* were also common and *O. dioica*, *Frit. formica* and *Frit. borealis* f. *intermedia* were pretty abundant, while *O. cophocerca* and *Frit. haplostoma* were rare in his collection from Banyuls. *Frit. scillae* is described as being common in the collection made at Villefranche. *Doliolum denticulatum*, *Dolioletta gegenbauri* and *Thalia democratica* also were found in VERNIÈRES' collection from Villefranche. Recently FENAUX (1959 a and b) reported six more appendicularians from Ville-

franche, they are *O. rufescens, M. abyssorum, Frit. haplostoma, Frit. fraudax, Frit. tenella* and *App. sicula*; besides, *Frit. borealis*. Thus the appendidularian fauna of the waters near Villefranche is raised to 21 species. *O. longicauda* was the commonest form there, too; then followed *O. dioica* and *O. fusiformis*. *Frit. pellucida, Frit. borealis* and *O. cophocerca* also occurred in pretty large numbers. The occurrence of *Thalia democratica* in this area is also recorded (1959 a, p. 7).

The occurrence of *M. abyssorum* was recorded by BERNARD (1954) from the waters off Alger. Later, the same author (1958) reports the occurrence of 21 appendicularians from the same waters; they are:

O. longicauda	*Frit. formica* f. *tuberculata*
O. intermedia	*Frit. formica* f. *digitata*
O. fusiformis	*Frit. gracilis*
O. dioica	*Frit. fraudax*
O. rufescens	*Frit. aequatorialis*
O. parva	*Frit. pellucida*
O. cophocerca	*Frit. borealis* f. *intermedia*
O. albicans	*Frit. borealis* f. *sargassi*
M. abyssorum	*Frit. venusta*
Steg. magnum	*App. sicula*
P. haranti	

Frit. borealis f. *intermedia* is described in her paper as *Frit. borealis* var. *mediterranea* and *Frit. borealis* f. *sargassi* is shown as f. *crassa*. There, *O. longicauda* is the commonest species, next *O. dioica* and then followed by *O. intermedia, O. albicans* and *O. cophocerca* in the order of abundance. *O. fusiformis* is the most scarce one among the species of *Oikopleura*. Of fritillarians, *Frit. pellucida* is the commonest one and followed by *Frit. formica* and then by *Frit. borealis* f. *sargassi*. Besides these appendicularians, occurrences of *Doliolum denticulatum, Doliolum nationalis* and the typical and *orientalis* forms of *Thalia democratica* are recognized by her. FURNESTIN (1958) examined the plankton collection made in the Gibraltar Straits and the adjacent Alboran Sea and found that *O. longicauda* and *O. dioica* occurred there and *O. longicauda* was much more abundant than *O. dioica*. She records *Thalia democratica* from the surveyed area, but the distinction between the typical and *orientalis* forms is not made. *Frit. formica* is known from the vicinity of Gibraltar, too. In the neighbouring waters of the Balearic Islands, *Doliolum denticulatum* is recorded at Palma of Mallorca and MASSUTI (1959) reports the common occurrence of *Thalia democratica* at Castellon, although the distinction between the typical and *orientalis* forms is not made. As to the doliolid fauna of the Mediterranean Sea, ULJANIN's monograph (1884) appeared in the series of the "Fauna und Flora des Golfes von Neapel" cannot be put aside, in which *Doliolum ehrenbergii* (=*denticulatum*), *D. gegenbauri* n. sp., *D. rarum*

and *D. mülleri* are given; BORGERT (1893) found *Doliolum nationalis* in the Mediterranean Sea and SIGL (1912) confirmed the occurrences of *Doliolum denticulatum*, *Doliolum nationalis* and *Dolioletta gegenbauri* in the collection made by the Pola-Expedition 1890–1894 in the Adriatic Sea, these three species were, however, not found in the eastern waters of much higher salinity.

The appendicularian fauna of the Black Sea is represented by a single species *O. dioica* as shown for instance by NIKITIN (1929), DOLGOPOLSKAIA (1940) and NEGREA & others (1959).

Summing up above-mentioned listings, the total of appendicularian species occurring in the Mediterranean Sea attains 33, two of which, *Frit. formica* and *Frit. borealis*, are divided respectively into two forms. The close relationship found between *Frit. charybdae* and *Frit. urticans* and that betweeu *Frit. tenella* and *Frit. scillae*, however, must be studied crucially in the future. Throughout the Mediterranean Sea, *O. longicauda* is the dominant-most species and next *O. dioica* at various parts of the Sea. *O. fusiformis* may occur rather abundantly at some places (Banyuls, Sète and Villefranche), but may be very scarce at others (Bay of Alger, etc.). *O. cophocerca* occurs frequently in considerable numbers, but *O. rufescens* is always quite rare in this sea. *Frit. pellucida* is the commonest species of fritillarians and followed by *Frit. formica* or *Frit. borealis*, while *Frit. haplostoma* is rare throughout the sea. The appendicularian fauna of this sea resembles closely that of the Atlantic. However, the scarcity of *O. rufescens* and *Frit. borealis* f. *sargassi*, the relative fewness of *O. fusiformis* and contrarily the existence of f. *tuberculata* of *Frit. formica* and relative abundance of *O. dioica* may be accepted as the characteristics of the appendicularian fauna of the Mediterranean Sea when the fauna is compared with that of the Atlantic; besides, the occurrence or absence of some special, not so common, species are noted as shown in Table 35.

(c) *The Gulf of Mexico* (Table 31). In order to be compared with the appendicularian fauna of the area surveyed by the Shellback Expedition, the fauna of the Gulf of Mexico is mentioned here separately. Throughout the works of LOHMANN (1896 b and 1916), BROOKS & KELLNER (1908), GARSTANG (1937) and TOKIOKA & SUÀREZ (1956), twenty-three species of appendicularians are known from the Gulf. Namely the following eight species are known in addition to the 15 species listed in Table 31.

O. intermedia (=*O. tortugensis* BROOKS & KELLNER 1908)
O. albicans
Alth. tumida
Bathochordaeus charon (=*B. stygius* GARSTANG 1937)
Frit. fraudax
Frit. tenella
App. sicula
K. tenuis

In Cuban waters, *O. longicauda* is the commonest species and next *O. dioica*, being followed by *O. rufescens* and *Frit. borealis* f. *sargassi*. *O. fusiformis* and *O. cophocerca* are much less than *O. rufescens*; of fritillarians *Frit. pellucida* is the second predominant species, though much less than *Frit. borealis* f. *sargassi*. The relatively abundant occurrences of *O. rufescens* and the low population of *O. fusiformis* are common to the appendicularian fauna of Cuban waters and that of the Shellback area. However, the occurrences of much more abundant *Frit. borealis* f.

Number of samples	47
O. longicauda	5293
O. fusiformis	304
O. fusiformis f. *cornutogastra*	330
O. graciloides	26
O. dioica	1533
O. rufescens	700
O. parva	261
O. cophocerca	207
Oikopleurids damaged	527
Steg. magnum	34
Frit. haplostoma	24
Frit. formica f. *digitata*	30
Frit. pellucida	117
Frit. borealis f. *intermedia*	26
Frit. borealis f. *sargassi*	608
Frit. megachile	10

Table 31. Abundance of respective appendicularians in Cuban waters shown in *Frequency of Occurrence* ×*Mean Percentage* (calculated on the data given by TOKIOKA and SUÀREZ 1956).

sargassi and *O. dioica* and the relatively lower population of *O. cophocerca* in Cuban waters differ significantly from the constitution of appendicularian fauna of the Shellback area. The occurrences of *O. fusiformis* f. *cornutogastra* in a significant number may be considered as unique for the fauna of Cuban waters. All these aspects seem to show that the appendicularian fauna of the Gulf of Mexico and that of the Shellback area resemble each other as their constitutions are both included in the general type found in faunas of the tropical waters, but

they do not show any further special relationship beyond this.

XIV. GENERAL DISTRIBUTIONAL ASPECT OF PELAGIC TUNICATES IN THE NORTH PACIFIC

(Tables 32–35)

1) *Vertical distribution of appendicularians* (Tables 32–33).

As most samples dealt with in the present paper were collected by vertical or oblique towing mostly from 50 m deep or from various depths beyond it, it is very important to examine first whether the centre of the appendicularian population is found in the surface layer shallower than 50 m or it is located more deeply. If the former is the case, then the trends deduced from comparing the data

Water layers	in port		in the strait	
0–1.5 m	302	497	65	419
1.5– 10	87		109	
10– 30	78		123	
30– 60	30		122	
60–100	—	—	62	139
100–150	—		75	
150–200	—		2	

Table 32. Distribution of appendicularian population at Messina (LOHMANN 1933, Table on p. 177).

Water layers in m.	0–50	50–100	100–200	200–400	400–600	600–800	800–1000	900–1100
Mean individuals	579	170	86	8.5	2	2	0.7	1.5
Percentages to the value of 0–50 m.	100	29.5	15	1.5	0.3	0.3	0.1	0.25
The maximum value observed	6587	1560	631.5	74	46	10.25	6.5	5
Frequency of occurrence of 0–value	2.7	2.7	0	5	18	18	36	31

Table 33. Number of appendicularian individuals per 50 m. haul in respective water layers in the South Atlantic (LOHMAMM & HENTSCHEL 1939, Table 40 on p. 190).

from samples from various depths one another may be accepted as general tendencies, while it would be quite unreasonable to compare the data from the shallower water samples with those from the deeper water samples if the latter were the case. It has been well known since LOHMANN's comprehensive studies (1896 b) on the appendicularian material of the Plankton Expedition that the important part of the appendicularian population lies in the upper 200 m layer, although

some species auch as *O. parva*, *Frit. tenella*, *Frit. megachile* and *Folia gracilis* often penetrate into much deeper layers. Further, as to the distribution within the surface to 200 m layer, there are two available data, one is LOHMANN's observation made at Messina and the other is the result of the "Meteor" Expedition in the South Atlantic. Although the densest population of appendicularians may be found in some cases in 100–200 m or 200–300 m layers as LOHMANN noted in the Sargasso Sea during the Plankton Expedition (1896 b) and in the Antarctic Sea during the "Deutsche Südpolar-Expedition" (1933, p. 178), the data given in Tables 32 and 33 seem to show that the most significant part of the appendicularian population is to be seen in the 0–50 m layer. On this general aspect of vertical distribution is based the comparison made in this paper between the data from samples collected by towing from various depths to the surface. As "in den obersten Wasserschichten im ganzen Warmwassergebiet *Oikopleura longicauda* VOGT und *fusiformis* FOL die herrschenden Arten sind" (LOHMANN 1933, p. 178), the distribution of F/L should be recognized as one of the most important trends found in the appendicularian distribution. The appendicularian fauna of the superficial water seems to differ considerably from those of deeper layers. LOHMANN mentioned about the appendicularian population at Messina that the density in superficial layer is much lower in the warm season than in the cool season. Generally speaking, appendicularians were few in the superficial layer, and some species such as *O. parva*, *Frit. tenella* and *Frit. megachile* could be seen only in deeper layers beyond the 30–60 m layer at Messina. Also remarkable discrepancies were found in the constitution of the appendicularian population between the samples collected by surface towing and those collected by vertical hauling in the Japan Sea (Tables 13–15). All these seem to show evidently that the fauna of the superficial layer is to be treated as a special one. Furthermore, there may occur unusually dense populations of some species in the superficial layer as AIDA (1907) met with swarms of *K. tenuis* or *O. rufescens* at Misaki Harbour or I observed a spawning swarm of *O. longicauda* in Tanabe Bay and dense swarms of *Frit. haplostoma* in some Japanese inlet waters (TOKIOKA 1955 a).

2) *Areas of abundant occurrences of appendicularians in the warm-water regions of the North Pacific.* Results of the present studies seem to show that appendicularians occur densely in the North Pacific in the *bedoti*-water along the east coast of the old continent, in the Shellback area harbouring both *Sagitta bedoti* and *Sagitta friderici* and also in the equatorial zone where plankton organisms are much more abundant than in the adjacent tropical waters (JOHNSON 1956 and KING & HIDA 1957)*. This aspect resembles somewhat the distribution of dense population in the Atlantic. On the other hand, number of species and quantity

* JOHNSON, M. W. (1956): Some outlines of plankton concentration in the eastern and tropical Pacific. Proc. 8th Pacific Sci. Congr., Vol. 3, pp. 379–390, 6 text-figs.
KING, J. E. and HIDA, T. S. (1957): Zooplankton abundance in the central Pacific. Fish. Bull. U.S., No. 118, pp. 365–395.

of individuals seem to be insignificant in the northeastern part of the Central North Pacific water mass, just as in the West Wind Drift in the North Atlantic.

3) *Constitution of the appendicularian population* (Tables 34 and 35).

Except for those in the neritic waters, the dense populations in the warm water regions of the North Pacific are assigned most frequently to the remarkable increase of *O. longicauda* and hence values of F/L are usually lowered in the areas where appendicularians occur in quantities. Also, the number of individuals of *O. fusiformis* seems to be raised in these areas, but the increase is considered to be much smaller than that of *O. longicauda*. While, in the area corresponding to "the *pacifica*-dominant waters" proposed on the distribution of chaetognaths in the North Pacific, F/L is raised significantly. Probably this is attributable to the sharp drop of *O. longicauda* in this waters, although we have to pay notices on such differences of F/L between the samples collected from different depths at the same station as that found between the samples TP 131 and TP 131B (Appendix Table 6-*4*). The relative abundance of *O. fusiformis* in the superficial water was observed also in some samples collected in the Japan Sea as already mentioned on p. 385. It is not impossible that *O. fusiformis* might be distributed more abundantly in the surface layer than in deeper lyyers under some conditions. However, the trend of F/L towards the increase in "the *pacifica*-dominant waters" may be safely accepted as real, as the decrease of *O. longicauda* is recognized definitely in the cooler waters in the middle part of the Atlantic. *O. longicauda* quite disappears near the front of the warm waters in the Atlantic, but in the North Pacific there have not yet been found any wide areas where *O. longicauda* disappears completely and *O. fusiformis* is keeping the absolute predominancy, although the complete absence of *O. longicauda* is recorded at some stations. Contrarily, in the areas where the warm water is mixed with the cold water in the North Pacific, *O. longicauda* is the most remarkable species of all warm water forms. This seems to be one of the most remarkable characteristics of the North Pacific appendicularian fauna differing from that of the North Atlantic and reasonably this is attributable to the differences of hydrographic condition between these two oceans. In the southern South Pacific, there is found an area where *O. longicauda* is quite absent and *O. fusiformis* is keeping the predominancy (BARY 1960, see p. 398). *O. rufescens* shows the trend towards the increase in the tropical waters and the same as to *O. cophocerca*, *M. huxleyi* and *Steg. magnum*, the latter three are, however, found only sparsely in the waters even in tropics, where the neritic character is retained remarkably as is the case in the Arafura Sea.

Important fritillarians are *Frit. borealis* f. *sargassi* and *Frit. pellucida* and followed by *Frit. formica*; this order of abundance differs somewhat from that in the Atlantic. *Frit. tenella* and *Frit. venusta* are considered common in the tropical oceanic waters in the Pacific. *Frit. haplostoma* occurs widely in every

collection, but not in abundance. In the Atlantic, evidently this species occurs abundantly in the coastal waters (p. 405), this is also true about the distribution of this species in the Pacific. Dense population of this species was recorded in the Pacific in Iwayama Bay of the Palao Islands, in Maizuru Bay on the Japan Sea coast of Honsyû Island, Japan and in Mori Inlet of Tanabe Bay near the Seto Marine Biological Laboratory. I have ever met with a dense population of this species along the southern coast near our laboratory, when the species occurred very abundantly in the superficial layer of a yellow brown water caused by a very small kind of ? *Diplopsalis*. On the other hand, the population of this species in the offshore oceanic water has never been raised to a significant degree. The possibility that *Frit. abjornseni*, an akin species to the present species, might be a neritic from, is mentioned already (p. 377), but here arises the possibility that the main propagating area of *Frit. haplostoma* is in the neritic waters and that individuals which are found in the far offshore oceanic waters and usually slightly larger may be drift forms. If this is true, *Frit. haplostoma* should be treated as a neritic water inhabitant just as *App. sicula* is done. Examining various collections, it seemed that individuals of *Frit. haplostoma* with wider tail musculature occurred more frequently and abundantly in samples from the eastern Pacific, for example the Shellback Expedition samples, but more crucial studies are needed to ascertain this inclination.

LOHMANN (1933, p. 106) mentioned that *Frit. aberrans* might be a deep water form. In the collections dealt with in this paper, this species occurred mostly in the deep water samples, too. Also *Tectillaria taeniogona* is considered to be a deep water form, because its state of preservation in samples collected by towing from, deep layers is mostly imperfect and more or less injured just as in *Frit. aberrans*.

O. dioica is the only appendicularian found in the strongly stagnant inlet waters or in somewhat brackish waters in the Pacific as in the Atlantic. The highest salinity 37.6‰ observed in Scammon's Lagoon on the west coast of Baja California is noted as a new record for *O. dioica*. *O. longicauda* is the commonest of all oceanic forms which are found in the embayments together with *O. dioica*. Abundant occurrences of *O. fusiformis* f. *cornutogastra* in the lagoon water of the Palao Islands and near the middle part of the Arafura Sea together with *O. dioica* are considered to be attributable to the low refreshment degree of the lagoon water by the ocean water.

The geographical distribution of appendicularians was mentioned by LOHMANN (1933) and THOMPSON (1948), and FORNERIS (1959) summarized the previously published features indicating the differences found among the appendicularian faunas of the Atlantic, Mediterranean Sea, Indian Ocean and the Pacific. TOKIOKA showed the outline of the fauna in the Japanese waters in his paper of 1955 a. Consequently it is needless to repeat again on this subject. Here, only lists of

	Gulf of Mexico	Atlantic	Mediterranean Sea	Indian Ocean	Pacific
O. longicauda	+	+	+	+	+
O. intermedia	+	+	+	+	+
O. fusiformis	+	+	+	+	+
O. fusiformis f. *cornutogstra*	+	+	−	+	+
O. gracilis	−	+	+	+	+
O. graciloides	+	+	+	+	+
O. dioica	+	+	+	+	+
O. rufescens	+	+	+	+	+
O. parva	+	+	+	+	+
O. cophocerch	+	+	+	+	+
O. mediterranea	−	−	+	−	+
O. albicans	+	+	+	+	+
M. huxleyi	−	−	−	+	+
M. abyssorum	−	+	+	−	+
Steg. magnum	+	+	+	+	+
Chunopleura microgaster	−	−	−	+	−
Folia gracilis	−	+	+	−	+
P. verticalis	−	+	−	+	+
P. oppressa	−	+	−	−	−
P. gracilis	−	+	−	? +	+
P. haranti	−	−	+	−	−
Alth. tumida	+	+	−	−	+
Sin. scrippsi	−	−	−	−	+
Bathochordaeus charon	+	+	−	−	+
Frit. haplostoma	+	+	+	+	+
Frit. abjornseni	−	+	−	+	+
Frit. arafoera	−	−	−	−	+
Frit. aberrans	−	+	−	−	+
Frit. formica f. *tuberculata*	−	−	+	−	−
Frit. formica f. *digitata*	+	+	+	+	+
Frit. fraudax	+	+	+	+	+
Frit. gracilis	−	+	+	+	+
Frit. charybdae	−	−	+	−	+
Frit. urticans	−	−	+	−	−
Frit. aequatorialis	−	+	+	−	−
Frit. helenae	−	+	−	−	−
Frit. drygalski	−	+	? +	−	−
Frit. pacifica	−	−	−	−	+
Frit. pellucida	+	+	+	+	+
Frit. borealis f. *intermedia*	+	+	+	+	+
Frit. borealis f. *sargassi*	+	+	+	+	+
Frit. megachile	+	+	+	+	+
Frit. tenella	+	+	+	−	+
Frit. scillae	−	+	+	−	−
Frit. venusta	−	+	+	+	+
T. fertilis	−	+	+	+	+
T. taeniogona	−	−	−	−	+
App. sicula	+	+	+	+	+
K. tenuis	+	+	+	−	+
K. oceanica	−	−	+	−	−
Number of species	23	38	35	28	40

Table 34. Occurrences of warm water-species of appendicularians in the world seas.

	Atlantic	Mediterranean Sea	Indian Ocean	Pacific	Notes
O. fusiformis f. *cornutogastra*	+	−	+	+	m
O. mediterranea	−	+	−	+	w
M. huxleyi	−	−	+	+	P
M. abyssorum	+	+	−	+	w
Chunopleura microgaster	−	−	+	−	n
Folia gracilis	+	+	−	+	w
P. verticalis	+	−	+	+	m
P. oppressa	+	−	−	−	n
P. gracilis	+	−	? +	+	m
P. haranti	−	+	−	−	M
Alth. tumida	+	−	−	+	m
Sin. scrippsi	−	−	−	+	P
Bathochordaeus charon	+	−	−	+	m
Frit. abjornseni *Frit. arafoera*	+ −	− −	+ −	+ +	w
Frit. aberrans	+	−	−	+	m
Frit. formica f. *tuberculata*	−	+	−	−	M
Frit. charybdae *Frit. urticans*	− −	+ +	− −	+ −	w
Frit. aequatorialis *Frit. helenae* *Frit. drygalski*	+ + +	+ − ? +	− − −	− − −	A
Frit. pacifica	−	−	−	+	P
Frit. tenella *Frit. scillae*	+ +	+ +	− −	+ −	w
T. taeniogona	−	−	−	+	P
K. tenuis *K. oceanica*	+ −	+ +	− −	+ −	w

Table 35. Warm water-species showing uneven distribution in the world seas. A···species occurring only in the Atlantic, M···species occurring only in the Mediterranean Sea, m···species missing in the Mediterranean Sea, but present in the Atlantic; n···species not yet sufficiently recognized, P···species occurring only in the Indo-Pacific, w···species presumably distributed widely in the world seas.

warm water species in respective seas are presented (Tables 34 and 35) and some brief notes will be given. Of fifty forms listed in Table 34, 28 species occur unevenly in the world seas. Then of these 28 species, *Chunopleura microgaster* and *Pelagopleura oppressa* are known only by extremely few individnals and there might be some doubts about their validity. *Frit. abjornseni* and *Frit. arafoera* belong to the "Formenkreis" of *Frit. haplostoma* and hence their presence or absence do not seem to be so significant for the appendicularian fauna of respective seas. *Frit. charybdae* and *Frit. urticans* are related very closely, and so are *Frit. aequatorialis—Frit. helenae—Frit. drygalski, Frit. tenella—Frit. scillae* and *K. tenuis—K. oceanica.* These couples or triplet may be treated here respectively as a "Formenkreis".

O. mediterranea, M. abyssorum, Folia gracilis, Frit. charybdae-urticans group, *Frit. tenella-scillae* group and *K. tenuis-oceanica* group are considered to be found distributing widely in all of these seas by future studies, although the first four belong to somewhat rare species. At present, *O. fusiformis* f. *cornutogastra, P. verticalis, P. gracilis, Alth. tumida, Bathochordaeus charon* and *Frit. aberrans* are known from both the Pacific and Atlantic, but not from the Mediterranean Sea; it is, however, not impossible that these might be discovered in the Mediterranean Sea in the future. On the other hand, *P. haranti* and *Frit. formica* f. *tuberculata* are the species unique to the Mediterranean Sea and the group of *Frit. aequatorialis* is the only one which can be said apparently characteristic of the South Atlantic and the Mediterranean Sea, being quite missing in the Indo-Pacific. There are following four species unique to the Indo-Pacific: *M. huxleyi, Sin. scrippsi, Frit. pacifica* and *T. taeniogona,* the latter three of which are known only from the Pacific to this date and do not occur so abundantly. Throughout the above-mentioned features of the geographical distribution, the absence of *M. huxleyi* in the Atlantic and the Mediterranean Sea, the confinement of the group of *Frit. aequatorialis* to the Atlantic and the Mediterranean Sea and the existence of *Frit. formica* f. *tuberculata* solely in the Mediterranean Sea may be accepted as the three important phenomena. In addition, the relative fewness of *O. rufescens* and *Frit. borealis* f. *sargassi* may be considered as a characteristic distributional aspect in the Mediterranean Sea and the abundant occurrence of *O. longicauda* in the northern mixing area between the warm water and the cold subarctic water is a remarkable feature characteristic to the North Pacific appendicularian fauna.

4) *Distribution of doliolums.* Although *Doliolina intermedia* is considered to occur most abundantly in the 200–1000 m layer of the ocean in the southern hemisphere (KRÜGER 1939), most other doliolids are evidently surface-water inhabitants as THOMPSON showed that *Doliolum denticulatum, Dolioletta gegenbauri* var. *tritonis* and doliolids Amme were caught mostly in the 50–0 m layer during the survey in south-eastern Australian waters (1948, p. 100). *Dolioletta gegenbauri* is treated

by some authors as a cool water species (BERRILL 1950), but apparently other doliolids are warm-water inhabitants. Even *Dolioletta gegenbauri* is reported from the tropical water, as RUSSELL and COLMAN (1935) collected it from the Great Barrier Reef region and TOKIOKA found it in the plankton collection from the Arafura Sea.

One of the most interesting subjects on doliolids must be the difference found between the distributions of *Doliolum denticulatum* and *Doliolum nationalis*. In the North Pacific, *Doliolum denticulatum* is distributed very widely and rather evenly in the whole warm oceanic waters, but it is quite absent or scarcely found in the Inland Sea of Japan, the Japan Sea and the inshore waters along the Californian coast; in these areas is found *Doliolum nationalis* which is, however, quite absent in the far offshore waters of the North Pacific. As to the distributional aspects of these two doliolids in the Atlantic, GARSTANG (1933) noticed that *Doliolum nationalis* occurred most abundantly in the equatorial zone during the Plankton Expedition and the "Tiefsee-Expedition" by the Valdivia and presented a supposition that this species, being found of the warm water, might be nothing but *denticulatum* differentiated early and arrested in growth and thus it might represent a quickly bred dwarf of the tropics. Later, KRÜGER (1939) notices that the areas rich of *Doliolum nationalis* were mostly located *near the coast* and that in the western section of the Guinea Current where *Doliolum denticulatum* was predominant during the "Meteor"-Expedition—"Dort aber, wo die Temperaturen über grosse Strecken gleich hoch bleiben, findet man *Doliolum nationalis* in *den nahrungsreichen Gebieten*". Of course, it is impossible to regard *Doliolum nationalis* as a cool-water species, but in the North Pacific this species does not seem to be distributed in the waters warmer than those in which *Doliolum denticulatum* is prevailing. Evidently the species is distributed much more northerly than *Doliolum denticulatum* in the Japan Sea and the north-eastern waters of Japan. ZYL (1960) mentions that *Doliolum nationalis* has its highest incidence during winter in the waters off the west coast of South Africa. The distribution of *Doliolum nationalis* in the North Pacific seems in most parts to conform well to that of a chaetognath, *Sagitta bedoti*, and partly to that of *Sagitta friderici* along the southern Californian coast. Most probably, at least in the North Pacific, *Doliolum nationalis* is considered to be distributed in the "*bedoti* and *friderici* waters" which are usually found along or near the coast and rich of nutrient microorganisms; these features resemble those of the distributional region of *Doliolum nationalis* in the Atlantic mentioned by KRÜGER. The distribution of *Doliolum nationalis* in the Atlantic seems to conform roughly to that of *Sagitta friderici*, too. For these reasons, I hesitate to accept GARSTANG's theory as to *Doliolum nationalis*, rather I prefer to consider that *Doliolum nationalis* is a form distinctly differentiated in the special water-mass, "*bedoti*"-or "*friderici*"-water, from the ancestor common to this and *Doliolum denticulatum*, although I can not

judge exactly if the degree of this differentiation has already attained the level of a distinct species, that of a subspecies or a variety.

As to the morphological differences between *Doliolum denticulatum* and *Doliolum nationalis*, there is nothing to be added about the internal structure; only I want to note here that a reddish orange pigment fleck near the dorsal ganglion can be observed or retained much more frequently in *Doliolum nationalis* than in *Doliolum denticulatum*. This pigment fleck can be found on nearly all gonozooids or phorozooids of *Doliolum nationalis*. For instance, I examined in the end of 1956 quite optionally the whole specimens found in the Shellback samples SB 118 and SB 137 and found that two specimens from SB 118 and about 500 individuals from SB 137 were all provided with the pigment fleck. On the other hand, individuals of *Doliolum denticulatum* having such a pigment fleck were very few during the Shellback Expedition, the following are the percentage proportions of individuals having the pigment fleck in the examined samples.

(SB 137)	2 of 33 individuals	6.1%
(SB 142)	3 of 41 individuals	7.3
(SB 160)	1 of 35 individuals	2.9
(SB 200)	11 of 138 individuals	8.0
(SB 210)	7 of 19 individuals	36.8

Those individuals having the pigment fleck seemed to be rather small. The maximal body length of *Doliolum denticulatum* in respective samples varied from 4.6 mm (SB 105)~5.2 mm (SB 115) to 9.1 mm (SB 109), while that of *Doliolum nationalis* was 3.6 mm (SB 112) or 3.9 mm (SB 115).

The distribution of *Doliolette gegenbauri* var. *tritonis* in the North Pacific resembles very closely that of *Doliolum nationalis*. Although ZYL (1960) considers this form might be an oceanic form, it is very possible that its distribution is closely related with the "*bedoti*"-or "*friderici*"-waters. It seems, however, that the distribution of this species is extended more towards the ocean centre than that of *Doliolum nationalis*. The results of oceanographical observations made in the sea east of Honsyû Island May—June, 1959 (Oceanographic Section of Japan Meteorological Agency 1960) show distinctly the above-mentioned distributional features of *Dolioletta gegenbauri* var. *tritonis*. Namely, this doliolum occurred very abundantly in the surveyed area together with *Doliolum denticulatum*. The former was, however, distributed in the inshore waters along Bôsô Peninsula and extending northwards to the 10°C isotherm and also in wide stagnant water masses found along the northern side of the main stream of the extension of the Kurosio, stretching in the areas respectively between 144° E and 152° E, and 154° E and 158° E, but it scarcely appeared in the waters south of the main stream of the Kurosio. On the other hand, *Doliolum denticulatum* occurred most abundantly in the waters south of the main stream of the Kurosio, although small numbers of individuals were found together with the preceding species in

the northern waters beyond the Kurosio between 154° E and 158° E and also in the inshore waters. The main stream of the Kurosio was traced to 157° E between 34° N and 36° N at that time (Fig. 13). Then it is rather strange that *Dolioletta gegenbauri* var. *tritonis* was not found in any collections made in the Japan Sea, though further studies are needed to ascertain whether or not the species is constantly absent in this sea.

The "Challenger" collected *Doliolum denticulatum* at various parts of the North and South Pacific (HERDMAN 1888), but it is quite unknown whether or not this involves *Doliolum nationalis*. The "Vettor Pisani" also recorded *Doliolum denticulatum* at many of her Pacific stations distributing along her course stretching between Callao of the eastern Pacific and Cape Batangan on the eastern coast

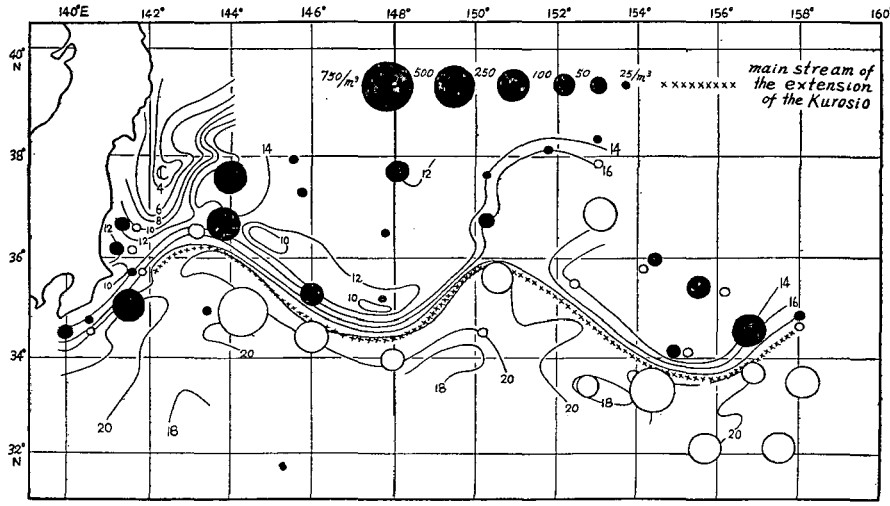

Fig. 13. Distributions of *Dolioletta gegenbauri* var. *tritonis* (solid circle) and *Doliolum denticulatum* (empty circle) in the sea east of Honsyû Island, with isotherms at 100 m layer. (Oceanographic Section of Japan Meteorological Agency 1960, Fig. 3-3 on p. 31)

of Annam via Hawaii and Philippines and *Dolioletta gegenbauri* var. *tritonis* at Hong Kong (BORGERT 1896). NEUMANN (1913, p. 31) found *Dolioletta gegenbauri* and *Doliolina krohni* in the collection of the "Planet" made at Hong Kong on Feb. 15, 1907. All these records are considered not to conflict with the above-mentioned general distributional aspects of the Pacific doliolids.

The doliolid fauna of the Shellback area seems to resemble closely that of the eastern part of the South Atlantic in harbouring *Doliopsoides* and considerable numbers of *Doliolina intermedia*, the distribution of the latter is also extended to the northern hemisphere in the Pacific.

5) *Distribution of salps.*

After THOMPSON listed previous works on Pacific salps in his book "Pelagic Tunicates of Australia" in 1948, six subsequent papers on Pacific salps have appeared, two by YOUNT (1954 and 1958) dealing with salps occurring in the Central Pacific, two by BERNER (1954 and 1955) treating two new salps and a newly discovered aggregated form of *Ritteriella picteti*, one by FAGETTI (1959) on salps occurring in the waters along the coast of North and Central Chile and one by BARY (1960) on the collection made in south-eastern New Zealand waters. Besides, there are TOKIOKA's fragmental notes and records of some salps came from various parts of the Pacific (TOKIOKA 1951 a, b; 1954, 1955 b, 1960; HANEDA & TOKIOKA 1954, TOKIOKA & BERNER 1958 b). Throughout the results of the

Thalia democratica	63%
Salpa fusiformis	43
Brooksia rostrata	17
Cyclosalpa pinnata	13
Salph cylindrica	12
Cyclosalpa floridana	5+
Pegea confoederata	5+
Iasis zonaria	5—
Thetys vagina	3
Traustedtia multitentaculata	3
Cyclosalpa affinis	2
Salpa fusiformis f. *aspera*	2
Salpa maxima	1
Ihlea punctata	1

Table 36. Frequency of occurrence of 14 Atlantic salps in 111 samples collected during the Plankton Expedition (from APSTEIN 1894, pp. 42–43).

examination published here and all those papers mentioned above or listed in THOMPSON's book, it is evident that *Thalia democratica* is the commonest salp occurring most frequently and abundantly in the warm water region of the Pacific. In the tropical waters, *Salpa cylindrica* is abundant next to the preceding species and followed by *Brooksia rostrata, Salpa fusiformis* and *Iasis zonaria* in samples towed in the surface 50–0 m layer; *Brooksia rostrata* is, however, very fragile in consistency and rarely found in a perfect condition. In samples hauled from deeper layers, *Salpa fusiformis, Ritteriella amboinensis* and *Metcalfina hexagona* are rather common. *Salpa fusiformis* increases in the temperate waters and con-

stitutes the most important part of the salp population in the mixing area between the cold subarctic water and the warm water in the North Pacific, while in the southern mixing area between the cold subantarctic water and the warm water *Salpa fusiformis* occurs commonly together with *Ihlea magalhanica*. In both northern and southern mixing areas, *Salpa fusiformis* is represented frequently by echinated forma *aspera*. Roughly saying, the above-mentioned distributional aspects of important salps seem to be common to the Pacific, the Atlantic and also to the Indian Ocean (Table 36).

As the occurrence of var. *orientalis* of *Thalia democratica*, characterized by having distally furcated atrial palps instead of distally pointed ones, has been reported only by SEWELL (1953) from the Indian Ocean, by YOUNT (1954) from the Central Pacific and by BERNARD (1958) from the Bay of Alger, besides TOKIOKA's fragmental notes, this variety seems to be confined to the Indopacific and the Mediterranean Sea, but quite missing in the Atlantic. Dealing with a considerable number of samples and gathering the data about *Thalia democratica*, I have tried to find out if the distribution of the typical form and that of var. *orientalis* are segregated from each other. However, so far as the results of the present examinations are concerned, the distributional aspect of the typical form and that of var. *orientalis* are quite similar, generally both forms occurring mingled with each other. It seems, however that var. *orientalis* is very common in the Japanese waters; this point will be made clear by further statistical studies in the future. The variety *orientalis* is also known from the South Pacific (TOKIOKA 1960).

6) *Concluding remarks.*

Throughout these observations, distributions of dense populations of appendicularins, values of F/L, *Doliolum nationalis* and *Dolioletta gegenbauri* var. *tritonis* in the North Pacific seem to support the idea that the "*bedoti*"-and "*friderici*"-waters, and probably also the *enflata*-dominant water in the equatorial zone, which were all proposed in my paper of 1959 on the basis of the distributional aspects of chaetognaths of the North Pacific, are separable from the far oceanic water of the North Pacific as distinct water masses. And this seems to prove that *Doliolum nationalis* is not an ecological form of *Doliolum denticulatum* but a distinct form differentiated in and confined to the special water mass.

At the same time, results of the observations on chaetognaths and pelagic tunicates of the North Pacific seem to show that some of the plankton animals living in the surface layer of the warm oceanic waters might be divided into the following groups:

1—Distribution confined to some (eutrophic) water masses

Sagitta bedoti, *Sagitta friderici*, *Doliolum nationalis* and ? *Dolioletta gegenbauri* var. *tritonis*

2—Distribution extending nearly to all parts of the ocean, but

a—Population density heightened remarkably in the eutrophic waters

Sagitta enflata and *Oikopleura longicauda*

b—i) Contrarily the density rather lowered there

Sagitta serratodentata pacifica, Oikopleura cophocerca, Oikopleura albicans, Megalocercus huxleyi and *Stegosoma magnum*

ii) or Population density without any remarkable increase in the eutrophic waters

Oikopleura fusiformis and *Oikopleura rufescens*

The eutrophic water masses harbouring *Sagitta bedoti, Sagitta friderici, Doliolum nationalis* and *Dolioletta gegenbauri* var. *tritonis* are the "*bedoti*"- or "*friderici*"-waters located near the coast, while the eutrophic waters harbouring rich *Sagitta enflata* and *Oikopleura longicauda* include the "*bedoti*"- and "*friderici*"-waters and the equatorial zone.

MORPHOLOGICAL NOTES ON SOME APPENDICULARIANS AND THALIACEANS

(Text-figs. 14–16)

1) *Colouration of some appendicularians.* Although the whole body may rarely be coloured violet, red or yellow in *O. longicauda*, the colouration most frequently observable in this species is a faint purplish tint found on the stomach and intestine, while the rectum is usually seen yellowish orange by its contents. This colouration can often be seen on living specimens of many other species. Rarely the anterior part of the trunk is coloured reddish brown in this species as well as in *O. fusiformis* and *O. dioica.* The orange stomach of *O. dioica* was observed in the vicinity of Seto, Japan and at Station 2 in the blue-green water along the southern Californian coast. On the other hand, the partial colouration in rose red seems to be rather usual in some species: rose red oikoplast epithelium was found once in a specimen of *O. rufescens* from St. 73 near the Palao Islands, rose red pharynx bottom holding the endostyle was observed in a specimen of *O. rufescens* from Palao, a specimen of *O. fusiformis* collected off Minabe, Kii Japan, Transpac Expedition specimens of *O. fusiformis* f. *cornutogastra* and a Transpac Expedition specimen of *O. intermedia*, rose red stomach in many specimens of *O. rufescens, O. intermedia* and *O. fusiformis* f. *cornutogastra* all collected in the surrounding waters of the Palao Islands and lastly scarlet pigmentation on the surface of testes was found in a single specimen of *O. rufescens* collected near Seto, Japan. Very strange is the reddish contents of the intestine found in a specimen of *O. longicauda* collected at the Transpac Expedition Station 135. The tail of *M. huxleyi* may look faintly pinkish against the white background, while bluish on the dark object; of course these are not the true colouration.

A specimen of *Frit. formica* was found having a series of reddish orange round pigment flecks along the middle of the tail (TOKIOKA 1951 b), and here is presented a specimen of *Frit. pellucida* collected in the vicinity of Seto, Japan, which is coloured dark reddish orange on the antero-ventral portion of the trunk, while the stomach is yellow and transparent, the intestine yellow and opaque, the gonad milky and spiracles are whitish.

2) *Colouration of some thaliaceans.* Living specimens of *Dolioletta gegenbauri* var. *tritonis* are often coloured faintly in purplish, but those found in a swarm appeared near our laboratory on January 25, 1939 were coloured faintly reddish brown as a whole, the stomach being quite transparent like an oil drop and the right postero-ventral side of the coil of the alimentary organ pigmented in reddish orange.

The nucleus of *Salpa fusiformis* or *Salpa cylindrica* is yellowish white or yellowish in smaller specimens, but it is coloured reddish orange and dark greenish or greenish brown in larger specimens in both solitary and aggregated forms. The nucleus of *Thalia democratica* is whitish in smaller individuals, but yellowish or orange in the grown ups. Both the solitary and aggregated forms collected at the Sôyô-maru Station 30, 1939 near the southern end of Kyûsyû Island, Japan had nuclei unusually coloured in vermilion. The nucleus of *Pegea confoederata* is usually purplish brown. The intestinal loop of the aggregated form of *Cyclosalpa affinis* is yellowish brown or greenish yellow.

3) *Subchordal cells in some species of Oikopleura* (*Vexillaria*) (Fig. 14).

(a) *O. cophocerca*: The tail musculature of this species seems to be comparatively rigid so that the tail is found in a satisfactory state of preservation in most samples. Subchordal cells varies much in number; usually they are ±9 in matured specimens, but they may be up to 12 in specimens collected near our laboratory and attain 17 in a Palao specimen. The results of examination on 19 specimens came from Seto and Palao show the following numbers of subchordal cells.

3 cells	1 individual	11 cells	2 individuals
5	1	12	1
6	3	13	2
7	2	14	1
8	4	17	1
10	1		

In younger specimens they are most often 4, although they may be 3 (in addition to the above-listed individual, a specimen from SB 145), 2 (a specimen from MP 2) or completely missing (specimen from SB 166, Station 78 in the neighbouring waters of the Palao Islands). Frequently they are found being divided into two groups as mentioned already in my previous note (1955 c). The tail having four subchordal cells reminds us of that of *O. najadis* which has also four subchordal cells and a comparatively wide musculature.

(b) *O. parva*: Four subchordal cells may be arranged in two groups as in some young specimens of *O. cophocerca* (Fig. 14D). The tail musculature is, however, much narrower than in the preceding species.
(c) *O. albicans*: Many individuals collected at the station SB 195 of the Shellback Expedition were remarkable in that subchordal cells were much fewer than usual or quite obsolete, although it was quite unknown what the cause was.
4) *Size of some appendicularians.*
(a) *O. fusiformis* f. *cornutogastra*: AIDA (1907) mentioned that his specimen was 1049μ in trunk length and THOMPSON (1948) stated that maximal trunk length was 2.0 mm in south-eastern Australian waters. The specimens collected in the lagoon waters of the Palao Islands were, however, somewhat smaller than in those

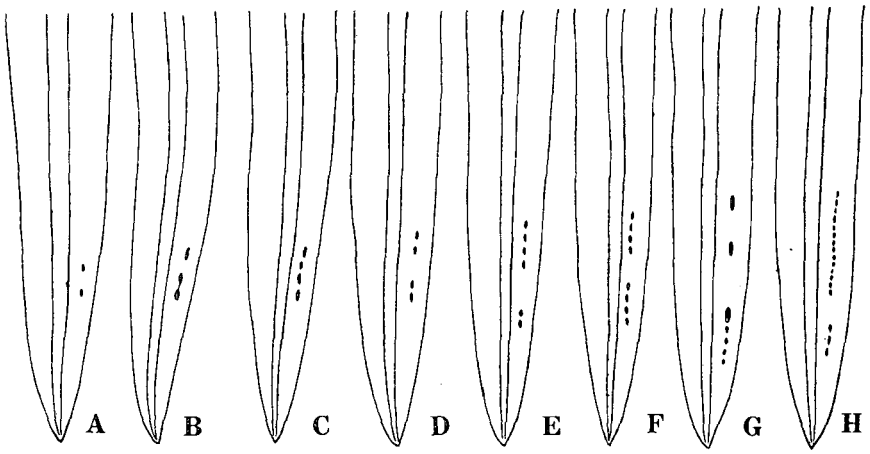

Fig. 14. *Oikopleura cophocerca* GEGENBAUR. Tails with various numbers of subchordal cells. A···specimen from MP 2, B···MP 20–J 62 and J65, C···TP 95; D, E···MP35–J 69, F···Palao specimen, G···SB145, H···Palao specimen. MP··· Midpac Expedition station, SB···Shellback Expedition station, TP··· Transpac Expedition station.

described by previous authors, they were mostly 600–800μ in trunk length, the maximum was 985μ and the minimum of the matured specimens was 362μ.
(b) *O. dioica*: While I was examining the specimens of this species collected in the blue-green water along the southern Californian coast, I found a 325μ long (in trunk length) individual having the gonad in a half matured state and this seemed to be the minimum of matured individuals in that collection.
(c) *M. huxleyi*: The specimens found in the collection made in the neighbouring waters of Korea were very large, ranging from 3.5 to 4.5 mm in body length and 15–18 mm in tail length, although these values are slightly less than those recorded by THOMPSON (1948) in south-eastern Australian waters, 5.8 mm in body length and 20 mm in tail length.

(d) *Bathochordaeus* sp.: The tail specimen found in the sample from the Shellback Expedition Station SB 170 was 18 mm long, 6.5 mm wide at the broadest level and with the 2 mm wide musculature and considered apparently to belong to a certain appendicularia. The similar piece came from SB 68 was ca. 20 mm in length and 8.0 mm wide at the distal end where the tail fin seemed to have its maximum breadth. It is quite impossible that such large and strangely shaped tails belong to another form else than *Bathochordaeus* sp.; very probably these are tails of *B. charon*.

(e) *Frit. formica*: A specimen from the Shellback Expedition Station SB 40 was

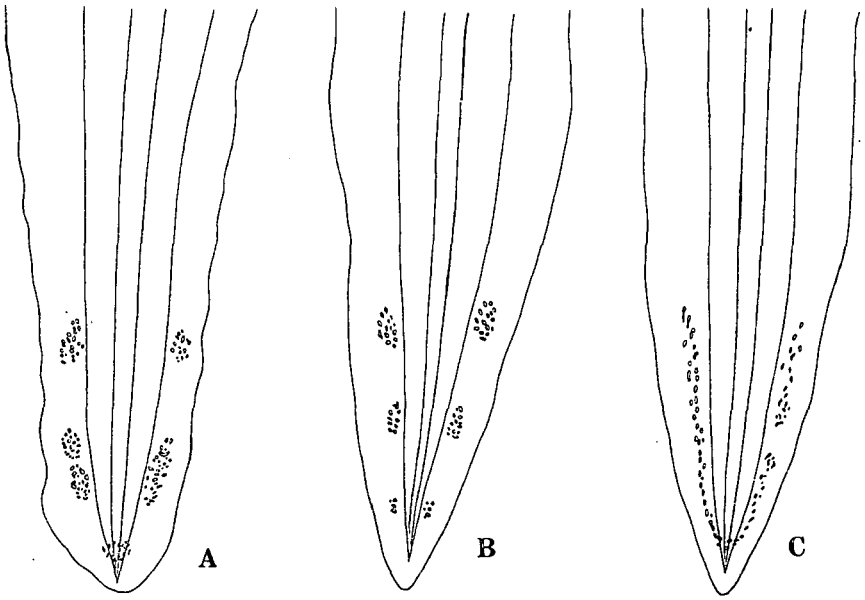

Fig. 15. *Pelagopleura verticalis* (LOHMANN). Different arrangements of amphichordal cells on the tail in specimens collected off southern California.

2.0 mm in trunk length and 4.1 mm in tail length. Probably this size is the new record for the present species.

5) *Morphology of some appendicularians* (Text-fig. 15).

(a) *O. rufescens*: The vertically descending rectum is available as a very useful character of this species when imperfectly preserved specimens are treated for identification.

(b) *Steg. magnum*: The posterior end of the left stomach lobe is rounded in younger individuals, but it becomes acute in old individuals.

(c) *P. verticalis*: Several specimens collected in June 1951, 160 miles off Baja California near islands were offered me for examination by courtesy of Dr. LEO BERNER. Gonads are arranged in just the same way as that found in those

specimens described by TOKIOKA (1955 a) The width of chorda is 30 to 37.5% of that of the musculature and 34.4% on an average. Amphichordal cells are usually divided into several groups, but the grouping may become quite obsolete in some specimens. I am inclined to consider that three LOHMANN's species, *P. verticalis*, *P. oppressa* and *P. gracilis*, are quite identical with one another and belong to the single species represented by *verticalis* according to the page priority. Very probably *P. oppressa* is the youngest form, then *P. verticalis* and *P. gracilis* is the fully matured one.

(d) *Frit. haplostoma*: Frequent occurrences of individuals having broader tail musculature in the eastern Pacific is mentioned already on p. 416 For example, 15 specimens from the Shellback Expedition Station SB 60 consisted of 9 individuals having wider musculature and five with very narrow musculature. Generally speaking, specimens with wider musculature are provided with roundish spiracles.

(e) *Frit. fraudax*: Superficially this species resembles *Frit. gracilis* and the resemblance is especially remarkable in immature individuals. However, young individuals of *Frit. fraudax* can be separated distinctly from those of *Frit. gracilis* by having much broader tail musculature and relatively larger alimentary organ. In *Frit. fraudax* there is a prominent triangular glandular projection on the left side of stomach and a couple of minute gland cells are found along the posterior margin of this projection.

(f) *Frit. borealis* f. *sargassi*: Usually the posterior side of the trunk is rounded and has a small prominence at the middle (TOKIOKA 1950), while a specimen from the Transpac Expedition Station TP 93 was found being truncate at the posterior end of the trunk even in a perfectly preserved state.

(g) *Frit. tenella*: Some authors seem to be of the opinion thas this species might be identical with *Frit. megachile*. In addition to that the latter has much more elongate trunk and a pair of amphichordal cell groups of quite different structure, there is further a more distinct difference between these two species and this may be used as an easy clue distinguisning these two species from each other. The stomach and intestine of *Frit. magachile* are surfaced very simply and without any glandular appendages, while the intestine of *Frit. tenella* is always provided with several appendages or prominences. The tail fin widely and clearly cut in at the distal end may be accepted as a sign to show the specimen may belong to *Frit. megachile* or *Frit. tenella*.

6) *Characteristics of Thalia democratica* var. *orientalis* (Text-fig. 16).

As I stated already in my short note dealing with the specimens collected near Noumea, New Caledonia, the bifurcate appearance of atrial palps of var. *orientalis* can be seen even in a very earlier stage of development of solitary form. For instance, a 2.5 mm long (excluding the protuberances) individual just left the mother individual found in the sample collected at SB 187 was found

having already bifurcate palps. Intermediate forms are seldom found between the typical and *orientalis* forms. As far as the specimens dealt with here in this paper are concerned, only three individuals are considered to show intermediate states. One of the three typical forms from SB 130 had the palps shown in B of Fig. 16, and two of 310 typical forms from SB 137 were provided with palps shown in C of the same figure. When the typical and *orientalis* forms are captured together, they are often separable from each other by their different appearance of the body. For example, typical forms may be rather rigid in body consistency and furnished with stouter muscles, while *orientalis* forms may be somewhat soft and provided with narrower muscles. This seems to show evidently that these two forms can not be merely insignificant intraspecific variants found among the individuals belonging to the same stock, but they might belong respectively to different stocks.

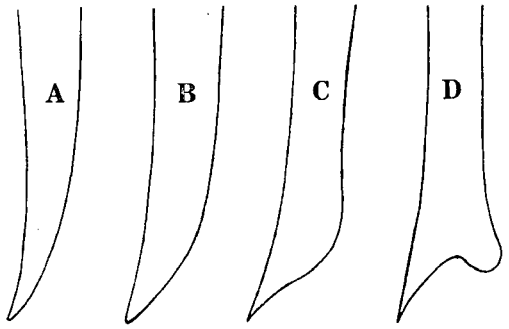

Fig. 16. *Thalia democratica* (FORSKÅL), solitary form. Atrial palp of A···typical form, D···var. *orientalis* TOKIOKA, B and C···? possible intermediate forms found in stocks of the typical form.

7) *Parasitic organism of appendicularians.* In the inner parts of Tanabe Bay near our laboratory, *O. dioica* is often found infested by club-shaped spores of *Gromia* sp. on the body surface.

SUMMARY AND CONCLUSIONS

1. Pelagic tunicates found in the same plankton collections with those treated in my previous paper (1959) on the taxonomy and distribution of chaetognaths of the North Pacific were examined and the crude data are given in 13 appended tables Data from samples collected in the Japanese and adjacent waters, the surrounding waters of the Palao Islands, the Arafura Sea and the Indian Ocean are also given in 6 appended tables. Besides, available data from

various publications were examined so that the distribution of pelagic tunicates of the North Pacific could be compared with those of other seas.

2. In all 40 forms of appendicularians were found in the material, four of these are known only from the Indo-Pacific, while the group of *Frit. aequatorialis* is quite missing in the Indo-Pacific. The constitutions of the population of the North Pacific warm-water appendicularians resembles roughly that of the Atlantic. However, the occurrence of rich *O. longicauda* in the northern mixing area between the subarctic and warm waters seems to be unique to the North Pacific.

3. Dense populations of appendicularians and lower values of F/L are seen in the North Prcific in the "*bedoti*"- or "*friderici*"-waters and also in the equatorial zone, while the density is low and the number of occurring species is few in the north-eastern quarter of the North Pacific Central Water Mass.

4. *Frit. haplostoma* and *App. sicula* might belong to the neritic form rather than to the oceanic form.

5. *Doliolum nationalis* is a distinct form quite differentiated from *Doliolum denticulatum* and its distribution seems to be confined to the "*bedoti*"- or "*friderici*"-waters in the North Pacific. The distribntion of *Dolioletta gegenbauri* var. *tritonis* is possibly related closely that of *Doliolum nationalis*.

6. The distributional aspects of dense appendicularian populations, values of F/L and *Doliolum nationalis* seem to support that the "*bedoti*"- or "*friderici*"-waters are separable from the far oceanic water mass as distinct water masses. The first two of three items are considered to approve the existence of a special eutrophic water mass in the equatorial zone.

7. The typical form and var. *orientalis* of *Thalia democratica* occur in the North Pacific, being mingled with each other.

8. ESSENBERG's appendicularian species are wholly reviewed, and some morphological notes are given on some pelagic tunicates.

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SUPPLEMENT

After the manuscript of the present paper was sent out to be printed, three more papers on pelagic tunicates were published and two other important papers were found overlooked. They are:

(1) FURNESTIN, M. L. (1960): Zooplancton du Golfe du Lion et de la cote orientale de Corse. Rev. Trav. Inst. Pêches marit., Vol. 24, No. 2, pp. 153–252.

Descriptions about pelagic tunicates are given on pp. 160 and 202–203. *Oikopleura longicauda* and *Thalia democratica* were the commonest forms in the surveyed area. Two doliolums were recorded, *Doliolum denticulatum* was met with only exceptionally, while *Doliolum nationalis* was found commonly in the Gulf of Lion in the range affected by the Rhone, but quite absent in the offshore water out of the southern border of the gulf and in the waters off the eastern coast of Corsica.

(2) BERNER, L. D. (1960): Unusual features in the distribution of pelagic tunicates in 1957 and 1958. California Cooperative Oceanic Fisheries Investigations Reports, Vol. 7, pp. 133–135.

Occurrences of *Dolioletta gegenbauri* and *Doliolum denticulatum* in the coastal water off Lower California are mentioned. The former is considered as an indicator of the California Current or subarctic water, while the latter is treated as that of the Central or sub-tropical water.

(3) DEEVEY, G. B. (1960): The zooplankton of the surface waters of the Delaware Bay region. Bull. Bingham Oceanogr. Collection, Vol. 17, pp. 5–53.

The occurrence of pelagic tunicates is mentioned on pp. 36–37. *Oikopleura longicauda, O. dioica, O. labradoriensis* and *Fritillaria borealis* appeared in the bay and did also *Doliolum nationalis, Dolioletta gegenbauri, Salpa fusiformis* and *Thalia democratica*. Among these, *O. dioica* and *D. nationalis* were the two tunicates which appeared regularly each summer or fall, usually during the same period. This seems to show evidently the occurrence of *D. nationalis* in the inshore waters.

(4) KADO, Y. (1954): The seasonal change of plankton and Hydrography of the neighbouring sea of Mukaishima. Jour. Sci. Hiroshima Univ., Ser. B, Div. 1, Vol. 15, Art. 6, pp. 193–204.

Mukaishima is located slightly west to the middle part of the Inland Sea. *Oikopleura dioica* was the commonest form of all pelagic tunicates. Besides, *Fritillaria haplostoma* occurred in August-November, 1949, *Dolioletta gegenbauri* var. *tritonis* made an unexpectedly sudden appearance on Dec. 7, 1949 and *Salpa fusiformis* on June 21, 1949.

(5) FURNESTIN, M. L. (1957): Chaetognathes et zooplancton du secteur atlantique Morocain. Rev. Trav. Inst. Pêches marit., Vol. 21, Nos. 1–2, pp. 1–356.

Occurrences of appendicularians are recorded on pp. 51 and 93–108. In this *friderici*-water, *Oikopleura dioica* occupied the greatest part (70%) of the appendicularian fauna and next *Oikopleura longicauda* (24.2%)

STATION DATA

1. Station data for the sampling stations in the neighbouring waters of the Palao Islands.

Station Number	Position	Data	Settling volume of plankton
14	8°00′ N×134°45′ E	Oct. 15, 1939	6.3 cc
15	8°10′ N×134°45′ E	„	2.7
17	7°01′ N×134°27.0′ E	Apr. 9, 1940	1.2
18	6°52′ N×134°20.3′ E	„	1.1
19	6°48.5′ N×134°10.4′ E	10,	1.0
20	6°45.3′ N×134°07.4′ E	„	0.7
21	7°05.9′ N×134°08.0′ E	11,	1.8
22	7°03.1′ N×134°06.8′ E	„	3,8
23	7°18.2′ N×134°07.7′ E	12,	2.4
24	7°17.7′ N×134°05.4′ E	„	1.3
25	7°32.6′ N×134°18.8′ E	13,	1.3
26	7°35.0′ N×134°20.6′ E	„	1.4
27	7°44.2′ N×134°27.0′ E	14,	2.5
28	7°47.8′ N×134°26.7′ E	„	1.4
29	8°04.0′ N×134°36.2′ E	15,	1.5
30	8°03.2′ N×134°32.5′ E	„	2.6
31	8°03.4′ N×134°47.8′ E	16,	1.3
32	8°06.3′ N×134°45.5′ E	„	1.2
33	7°30.7′ N×134°47.2′ E	17,	1.4
34	7°30.8′ N×134°46.0′ E	„	1.2
35	7°15.7′ N×134°47.0′ E	18,	2.2
36	7°14.0′ N×134°45.8′ E	„	0.8
59	5°30′ N×136°20′ E	Jan. 16, 1940	0.3
60	5°30′ N×136°19′ E	„	0.4
61	6°22′ N×136°14′ E	17,	0.3
62	6°35′ N×136°07′ E	„	0.6
63	6°25′ N×137°28′ E	18,	0.6
64	6°26.5′ N×137°21.5′ E	„	0.9
65	7°30.5′ N×137°29′ E	19,	0.7
66	7°31′ N×137°27.5′ E	„	0.8
67	7°30′ N×136°26.5′ E	20,	0.2
68	7°30′ N×136°23′ E	„	0.5
69	8°46′ N×136°29.7′ E	21,	0.3
70	8°42′ N×136°26′ E	„	0.3
71	8°39′ N×135°20.5′ E	22,	0.1–
72	8°43′ N×135°14′ E	„	0.4

Station Number	Position	Data	Settling volume of plankton
73	7°43′ N×135°24′ E	Jan. 23, 1940	0.25 cc
74	7°51′ N×135°23′ E	„	0.3
75	5°38′ N×131°40 E	Feb. 5,	0.2
76	5°41′ N×131°43′ E	„	0.1−
77	4°30′ N×131°40′ E	6,	2.5
78	4°27′ N×132°05′ E	„	3.8
79	3°24′ N×131°40′ E	7,	4.7
80	3°23′ N×132°05′ E	„	7.9
81	2°08′ N×131°30′ E	8,	6.9
82	2°02′ N×131°30.5′ E	„	6.2
83	3°08′ N×132°40′ E	9,	6.9
84	3°09.5′ N×133°01′ E	„	9.2
85	4°22′ N×133°58′ E	10,	3.4
86	4°12′ N×134°10′ E	„	5.4

2. Station datum for a sampling station during the Palao-New Guinea Cruise, March 1940

1	6°58′ N×134°29′ E	Mar. 17, 1940	0.8 cc

3. Station data for the samples collected by the Syunpû-maru in the Japan Sea and the Tugaru Straits in 1930

Station Number	Position	Date	Haul Distance
7	37°01′ N×131°13′30″ E	July 3, 1930	40–0 m
9	37°41′ N×130°21′ E	„	50–0
10	37°59′ N×129°51′ E	„	50–0
11	38°16′ N×129°22′ E	„	
12	38°34′ N×128°52′30″ E	4,	
13	38°54′ N×128°20′ E	„	50–0
14	39°13′ N×128°00′ E	„	
26	40°48′50″ N×129°47′40″ E	13,	100–0
27	41°14′20″ N×129°48′05″ E	„	
36	40°50′ N×132°05′ E	23,	100–0
37	40°12′ N×132°48′20″ E	„	
56	38°25′ N×138°32′ E	Aug. 7,	100–0
57	37°21′45″ N×138°33′30″ E	9,	
58	38°14′30″ N×138°41′30″ E	„	
64	38°35′ N×138°51′ E	16,	50–0
65	38°52′50″ N×139°00′ E	„	
68	40°02′30″ N×139°36′30″ E	17,	50–0
69	40°18′30″ N×139°42′ E	„	

Station Number	Position	Date	Haul Distance
72	41°15′ N×140°10′20″ E	Aug. 17, 1930	
73	41°28′ N×140°31′30″ E	„	100–0
74	41°47′ N×140°41′ E	18,	
75	41°43′50″ N×140°39′ E	„	50–0
76	41°39′20″ N×140°36′30″ E	„	60–0
79	41°25′ N×140°40′ E	„	50–0
80	41°20′50″ N×140°41′ E	„	100–0
82	41°10′ N×140°43′40″ E	„	?50–0
83	41°04′40″ N×140°43′ E	„	50–0
88	41°10′20″ N×140°43′40″ E	20,	50–0
89	41°10′30″ N×140°42′30″ E	„	„
90	41°10′30″ N×140°41′10″ E	„	„
94	41°18′50″ N×140°30′15″ E	22,	„
95	41°24′20″ N×140°28′ E	„	„
96	41°27′30″ N×140°26′50″ E	„	„
97	41°29′50″ N×140°24′10″ E	„	„
98	41°42′15″ N×140°57′10″ E	24,	„
99	41°39′50″ N×140°57′40″ E	„	„
100	41°37′30″ N×140°57′20″ E	„	„
101	41°34′20″ N×140°57′ E	„	„
102	41°32′30″ N×140°57′ E	„	„
104	41°29′10″ N×140°35′15″ E	26,	„
105	41°16′50″ N×140°34′10″ E	„	„

INDEX

(For other species see Tables 1 and 34, and also appended tables.)

1—*1*

Stations	TP 19	TP 20	TP 21	TP 22	TP 23	TP 24	TP 25	TP 27	TP 28	TP 29	TP 30	TP 31	TP 32	TP 34	TP 35	TP 36	TP 37	TP 38
Oik. labradoriensis	27	2	24	11	19	13	299	11	7	26	120	2	3	7	8	69	202	25
Oikopleura spp. Damaged specimens or juv.		1	3		7	4	16				4			5			1	2
Frit. borealis f. *typica*		1	5	2	7		12		1							16	1	
Total number	27	4	32	13	33	17	327	11	8	26	124	2	3	12	8	85	204	27

1—*2*

Stations	TP 39	TP 40	TP 41	TP 42	TP 43	TP 44	TP 45	TP 46	TP 47	TP 48	TP 49	TP 50	TP 63	TP 64	TP 65	TP 66	F.O.	Mean percentage
Oik. labradoriensis	35	11	10	15	20	129	73	24	75	55	27	39	31	64	29	10	100	83
Oikopleura spp. Damaged specimens or juv.	2	1		2	2	8	36		4	6	6						53	13
Frit. borealis f. *typica*	2		54	119	5		4		2	16	1	11			1		53	20
Total number	39	12	64	136	27	137	113	24	81	77	34	50	31	64	30	10		

Appendix Table 1 (*1–2*). Appendicularians found in the Transpac Expedition samples from the subarctic waters.

2

Stations	Off San Diego	New Port Harbor	1	1′	2	3	4	5	6	7	8	9	10	10′	11	12	13	14	15	F.O.	Mean percentage
Oik. longicauda	1		17	9		2	4	1	1	1			1	1				64	7	63	1
Oik. fusiformis																		1		5	*
Oik. dioica	698	13	541	670	532	608	581	648	763	887	341	410	579	577	534	687	910	552	641	100	84
Oik. parva			2					1										1		16	*
Oik. labradoriensis					2	1				1		1					1	3	3	37	*
Frit. pellucida																1		2		11	*
Frit. borealis f. *typica*	16	1	104	92	84	63	62	79	300	203	57	90	202	331	153	83	182	33	56	100	15
Kow. tenuis													? 1							5	*
Total number	715	14	664	771	618	674	647	729	1064	1092	398	501	783	909	687	771	1093	656	707		
Number of species	3	2	4	3	3	4	3	4	3	4	2	3	4	3	2	3	3	7	4		

* ··· less than 0.5%

Appendix Table 2. Appendicularians from the blue-green water along the southern Californian coast.

3—*1*

Stations (01#)	1	2	3	4	5	6	7	8	9	10	13	14	15	16	17	18	19	20	21
Doliolum nationalis																			
Dolioletta gegenbauri var. *tritonis*																			
Doliolina spp.																			
Oik. longicauda	5	4				1	117	185	112	44	55	40	48	180	23	237	355	50	218
Oik. fusiformis																			1
Oik. dioica	1	3		3	4	5	2	4		11	27	16	4	3	5	21	31	7	8
Oikopleura spp. Damaged specimens or juv.	7	27	1	14	15	11		31	37	60	60	18	8	21	20	146	167	32	52
Frit. abjornseni																			
Frit. borealis f. *typica*											6					1	1		? 1
Frit. borealis f. *sargassi* Smaller individuals																			
Fritillaria spp. Damaged specimens or juv.																			
App. sicula																			
Total number	13	34	1	17	19	17	119	220	149	115	148	74	60	204	48	405	554	89	280
Number of species	2	2		1	1	2	2	2	1	2	3	2	2	2	2	3	3	2	4

3—*2*

Stations (01#)	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	F.O.	
Doliolum nationalis	6	2	2	2	31	36	12	2			1		2				29	
Doliolette gegenbauri var. *tritonis*						2											3	
Doliolina spp.					1								1				6	Mean percentage
Oik. longicauda	52	16	23	17	44	15	14	44	31	16	103	41	34	20	8	31	91	45
Oik. fusiformis	1				4	1	1	1	1			17	24	5	10	6	34	4
Oik. dioica	32	17	42	21	12	7	14	30	26	10	73	71	28	34	28	44	94	20
Oikopleura spp. Damaged specimens or juv.	51	14	18	13	21	7	12	17	11	10	38	113	109	53	61	54	97	39
Frit. abjornseni					3												3	4
Frit. borealis f. *typica*	2	1															17	1
Frit. borealis f. *sargassi* Smaller individuals												8	4	4	2	1	14	2
Fritillaria spp. Damaged specimens or juv.					1												3	1
App. sicula														2	1	1	9	1
Total number	138	48	83	51	85	30	41	92	69	36	214	250	199	118	110	137		
Number of species	4	3	2	2	4	3	3	3	3	2	2	4	4	5	5	5		

Appendix Table 3 (*1–2*). Pelagic tunicates collected in the waters off San Diego.

4—1

Stations	SB 1	SB 5	SB 10	SB 15	SB 20	SB 25	SB 30	SB 35	SB 40	SB 44	SB 50	SB 55	SB 60	SB 64	SB 68	SB 71	SB 75	SB 80	SB 85	SB 90	SB 95	SB 100	SB 105	SB 109	SB 112
Oik. longicauda	21	171	154	156	81	13	214	138	20	319	40	139	60	107	42	54	63	200	104	104	38	80	29	12	338
Oik. intermedia			1	3	27	1	1					3	1			3				2	7	1	11		2
Oik. fusiformis	35	28	157	4	15	1	21	9	6	21		60	89	5	12	26	53	1	2	8	7	2			13
Oik. fusiformis f. *cornutogastra*			26																						
Oik. gracilis		18	1							1		1													
Oik. graciloides		91	29										1			1					1				
Oik. dioica				2			1			3	2														12
Oik. rufescens		5	13	2	7	1	36	7	6	13		6	13	3	2	2	3	3		8	3	14	14		1
Oik. parva	1	13	43								9	6	1			3					1				
Oik. cophocerca	7	42	33	8	3	4	1	49	2	2	5	13	27	15	9	28	3	4		4	2	9	3		6
Oik. albicans	8		9	3	3	3	15	1	2	7	9	9	6	1	5	1	? 1	2	4	6		15	2		8
Oikopleura spp. Damaged specimens or juv.	L. 343 S. 125	67	143	283	146	15	51	62	35	81	28	502	208	167	71	105	171	44	120	143	200	385	137	11	52
Meg. huxleyi				14	13	16	6	2		7		8	19	5	4	3	1								
Meg. abyssorum																									
Steg. magnum	1		5	33	3	1	3	17	? 1	9	1	265	4	9		8		2			? 2				
Folia gracilis																									
Pel. verticalis	69		1				1		? 4			1									1		3		
Alth. tumida			10																						12
Sin. scrippsi																									
Bathochordaeus sp. Tail															1	? 1									
Frit. haplostoma			3; W. 3	2; W. 2			1		W. 1	2		2	6; W. 9		3; W. 2	2; W. 2	6	2			8; W. 1	2			
Frit. aberrans							1		1						1					2					2
Frit. formica f. *digitata*		10	11	1	2				1	3		2	1	3	5	5	4	2	1						
Frit. fraudax	1		18	1	1		1			1		3	7				1		1		1				
Frit. gracilis	2	7	2	1	1			3		1															
Frit. charybdae			1																						
Frit. pacifica		? 1	2									4											1		
Frit. pellucida	13	9	18	5			4	3		4		28	32	6	2	17	20	81			2				
Frit. borealis f. *intermedia*			2																						
Frit. borealis f. *sargassi* Larger individuals	40								24			—	—	—	3	7									
Smaller individuals	16		13	4					—			2	3	1	—	—	3								
Frit. megachile			3		1		1		1	6	2	2					2	1							
Frit. tenella	2	4	65							1	8	2	1				1								
Frit. venusta	24	1	19	3			1		2	5							1	2			5				5
Fritillaria spp. Damaged specimens or juv.	1	1	3	1	2		2	1				3	5			1		3		1					
Tec. fertilis	? 1												1			2									
Tec. taeniogona													1									1			3
App. sicula		1	1																						
Kow. tenuis			3								1														
Total number	654	525	792	528	305	55	361	292	106	486	105	1061	495	322	162	271	333	347	232	278	279	509	200	23	454
Number of species	13	15	27	16	12	8	16	9	13	17	9	19	18	10	12	16	14	11	5	7	13	8	7	1	11

L.···larger and S.···smaller specimens, W.···wide tail musculature

Appendix Table 4–*1*. Appendicularians of the Shellback Expedition.

Stations	SB 115	SB 118	SB 122	SB 125	SB 130	SB 132	SB 137	SB 142	SB 145	SB 150	SB 155	SB 160	SB 166	SB 170	SB 175	SB 180	SB 181	SB 187	SB 195	SB 200	SB 210	SB 215	SB 217	F.O.	Mean percentage
Oik. longicauda	379	102	15	16	141	357	48	101	79	44	36	104	60	139	222	72	609	121	16	108	119	377	100	100	34
Oik. intermedia	11	7					8	5	4	1	3						16	9			10			48	2
Oik. fusiformis	1	3		1			2	2			1	7		3	16		29	15	2	61	34	500	42	79	6
Oik. fusiformis f. *cornutogastra*												4								1	4	1		10	1
Oik. gracilis																								8	1
Oik. graciloides																		1				4	4	17	3
Oik. dioica		2										2					2						7	19	1
Oik. rufescens							56	50	22	41		10	21	3	14	1		46		268	14	17	91	73	7
Oik. parva																		? 3			? 1			21	2
Oik cophocerca							11	24	65	26	17	15	112	6	38	14	9	72		3	44	3		79	7
Oik. albicans	15	4	2	2		? 1	13	4	7	4	18	1	1	13	4	10	36	64	37	2	21			88	3
Oikopleura spp. Damaged specimens or juv.	229	55	48	57	106	172	123	57	75	43	59	41	14	69	121	133	102	94	113	113	103	348	178	100	37
Meg. huxleyi									1			1			3	1		4	1	11			2	42	3
Meg. abyssorum									1															2	*
Steg. magnum							5	4	1	4			4	1	41			10		8	7	4	13	58	3
Folia gracilis								1																2	*
Pel. verticalis							? 1	? 1										1						21	2
Alth. tumida	2	1	3	9																				13	3
Sin. scrippsi				2					? 1	1						juv. 3								8	1
Bathochordaeus sp. Tail														? 1							? 1			8	*
Frit. haplostoma																? 1						5; W. 2		31	1
Frit. aberrans	1						6				1	2		3		8		2		1	14			29	1
Frit. formica f. *digitata*							1				1	1	1	4	5	2		3		1	5	4		52	1
Frit. fraudax																						3		25	*
Frit. gracilis														2										17	*
Frit. charybdae																								2	*
Frit. pacifica							3				1					3								15	1
Frit. pellucide										1		4		1	12	1	1	11			18	10		50	3
Frit. borealis f. *intermedia*																						17		4	1
Frit. borealis f. *sargassi* Larger individuals Smaller individuals																— 1	— 1	4 1			7 —	7 1	9 1	33	3
Frit. megachile							2	1	1					1	1			1						31	*
Frit. tenella										3						2		2			3	11		27	2
Frit. venusta	4		3				11			1			1	2				1			4	6	1	44	1
Fritillaria spp. Damaged specimens or juv.					1		3	1			1	3				7						16		40	1
Tec. fertilis										2					? 1	19		1						15	1
Tec. taeniogona	1					5								1				24						15	1
App. sicula																								4	*
Kow. tenuis																						2		6	*
Total number	643	174	71	87	248	535	298	251	257	171	138	195	214	276	478	278	805	490	169	577	409	1338	448		
Number of species	8	6	4	5	1	3	13	10	10	11	8	11	7	14	11	14	8	20	4	10	16	16	9		

* less than 0.5
F.O.···Frequency of Occurrence
W.···wide tail musculature

Appendix Table 4–*2*. Appendicularians of the Shellback Expedition.

Stations	SB 1	SB 5	SB 10	SB 15	SB 20	SB 25	SB 30	SB 35	SB 40	SB 44	SB 50	SB 55	SB 60	SB 64	SB 68	SB 71	SB 75	SB 80	SB 85	SB 90	SB 95	SB 100	SB 105	SB 109	SB 112
Pyrosoma atlanticum atlanticum small colonies	1				1	3	4	1		5	3	4	6		2		1			3		6	4		
Cyclosalpa pinnata				s. 1 g. 5	g. 5							g. 1						s. 2 g. 11							
Cyclosalpa floridana													s. 1			s. 1									
Cyclosalpa bakeri																									
Cyclosalpa strongyrenteron						g. 27					g. 26												g. 1	g. 1	g. 4
Brooksia rostrata					s. 22 g. 2			s. 1				s. 2													
Ritteriella amboinensis							s. 3 g. 2									s. 1	s. 2 g. 2								
Metcalfina hexagona					s. 2 g. 56									s. 3		s. 1									
Salpa fusiformia			s. 1 g. 1	g. 3			g. 9	g. 1			s. 1 g. 6	g. 1							g. 7	g. 3		g. 5			
Salpa cylindrica		s. 1	s. 1		s. 1 g. 3		s. 1	s. 9 g. 17		s. 1 g. 49	s. 1 g. 22		s. 1							g. 4	s. 1 g. 3				
Iasis zonaria									g. 1					g. 1				g. 7	g. 3	g. 1	s. 1 g. 1		g .1		g. 1
Thalia democratica sol. sol. var. *orientalis*			— 12 g. 19	74 10 g. 240		— 5 g. 11	— 1 —	1 2 g. 11		6 3 g. 31	— 1 g. 2	7 10 g. 93	12 3 g. 29	26 12 g. 42	2 — g. 1	— 9 g. 66	18 5 g. 64	— 1 g. 3	— — g. 5		— 4 g. 9	— 2 g. 15	— — g. 6		
Pegea confoederata			g. 14					1			s. 1 g. 1														
Traustedtia multitentaculata																									
Doliolum denticulatum			3	1	7	1	2	9		10		20	7		9	9	17	11	33	2	2	17	12	3	15
Doliolum nationalis	1										4														10
Dolioletta gegenbauri var. *tritonis*	1										4												11		102
Doliolina intermedia					15	3			70										1		26	63		5	1
Doliolina undulata																									
Doliolina obscura														? 1											
Doliolina separata																									
Doliolina spp.*			? 1				1															1		? 1	1
Doliolid Amme	50	1	38	142	100	42	24	6	14	37	114	92	112	31	23	29	9	94	17	47	33	183	105	10	130
Doliolid trophozooid			1				3			1	17					2			1		1	6			
Doliolids, damaged individuals or juv.												1	2				1								1
Doliopsoides horizoni																									
Doliopsis rubescens									1												1				

* Unidentified phorozooid, juv. or damaged individuals; s···solitary form, g···aggregated form

Appendix Table 5–*1*. Thaliaceans of the Shellback Expedition.

Stations	SB 115	SB 118	SB 122	SB 125	SB 130	SB 132	SB 137	SB 142	SB 145	SB 150	SB 155	SB 160	SB 166	SB 170	SB 175	SB 180	SB 181	SB 187	SB 195	SB 200	SB 210	SB 215	SB 217	F.O.
Pyrosoma atlanticum atlanticum small colonies	13	2							2	6										1				40
Cyclosalpa pinnata																								8
Cyclosalpa floridana																								4
Cyclosalpa bakeri	g. 2							s. 2		g. 1														6
Cyclosalpa strongyrenteron										g. 2														13
Brooksia rostrata																								6
Ritteriella amboinensis												s. 7 g. 14			s. 1 g. 1			s. 10 g. 2		s. 1 g. 6				15
Metcalfina hexagona																					s. 2			8
Salpa fusiformis																			s. 1					21
Salpa cylindrica	g. 2				s. 3		s. 7 g. 5		s. 6 g. 21			s. 3	g. 3					s. 1	s. 1	s. 6		s. 1	s. 5	44
Iasis zonaria	g. 2	s. 1							g. 6	g. 1		g. 3	s. 1		g. 1		g. 1			g. 4	g. 2			38
Thalia democratica sol. sol. var. *orientalis*					6 — g. 28		438 167 g. 4088	— 16 g. 41	4 17 g. 94	— 1 —		2 4 g. 19	2 6 —	— 1 —	10 7 g. 25		— — g. 2	3 3 g. 39		— — g. 25	16 — g. 33		1 — g. 5	35 50 58 } 67
Pegea confoederata																								6
Traustedtia multitentaculata								s. 2																2
Doliolum denticulatum	127	2		3			33	41	34	81	103	35	4	24	32	32	229	40	11	138	19		1	81
Doliolum nationalis	133	2	1	5	3		598	24	2	11	13	1			1	1			2	2		14	9	42
Dolioletta gegenbauri var. *tritonis*	6	380	150	19		3	99			1							1	4						27
Doliolina intermedia	23	15	79	74	19	5			9	10	1			1						10		1		42
Doliolina undulata	5					2	35	3		1							1	? 1			? 1	2		19
Doliolina obscura							50	2	1		16	? 1				3		6						17
Doliolina separata							+		+							+								6
Doliolina spp. *							14		1							? 1								17
Doliolid Amme	48	34	65	20	5	1	86	110	172	110	252	101	24	65	105	284	171	187	156	279	20	14	43	100
Doliolid trophozooid					1				1			2				1		2		1				29
Doliolids, damaged individuals or juv.	7	1		4	1	4	19	1	4	3						1	1	3						33
Doliopsoides horizoni	3	1	4	12			13	51	2	1	1													19
Doliopsis rubescens																								4

* Unidentified phorozooid, juv. or damaged individuals; s···solitary form, g···aggregated form F.O.···Frequency of Occurrence

Appendix Table 5–*2*. Thaliaceans of the Shellback Expedition.

Stations	TP1	TP3	TP4	TP6	TP7	TP8	TP9	TP10	TP11	TP12	TP13	TP14	TP15	TP16	TP17	TP18	TP26	TP33	TP51	TP52	TP53	TP55B	TP56	TP57A	TP58A
Oik. longicauda	491	33		1	1	11	49				51	110	273	209	246		1	1	12	11	4		6	21	4
Oik. intermedia																									
Oik. fusiformis	25	43	7	14	3	2	203	31	87	61		2								10	15				10
Oik. fusiformis f. *cornutogastra*																									
Oik. gracilis																									
Oik. graciloides																									
Oik. dioica	1	155																			4	2			
Oik. rufescens																									
Oik. parva																									
Oik. cophocerca	2	4																							
Oik. albicans						1																			
Oik. labradoriensis																4	2	5	25	14				13	5
Oikopleura spp. Damaged specimens or juv.	8	73	3	2		3	43	6	1	1		4		2	5				2	2	1	1		1	1
Meg. huxleyi																									
Steg. magnum																									
Alth. tumida																									
Frit. haplostoma																									
Frit. abjornseni																									
Frit. aberrans																									
Frit. formica f. *digitata*																									
Frit. pacifica																									
Frit. pellucida														1	3	18				1					
Frit. borealis f. *typica*	2	3								1				1					14	3			1	2	576
Frit. borealis f. *sargassi* Larger individuals / Smaller individuals	— / 12	— / 16	— / 7	— / 31	— / 3		— / 9	— / 7	— / 3	— / 13															
Frit. megachile										1															
Fritillaria spp. Damaged specimens or juv.	1																								
Tect. fertilis																									
App. sicula						1		1																	
Kow. tenuis																									
Total number	542	327	17	48	7	18	295	45	91	77	51	116	273	213	254	22	3	6	53	41	24	3	7	37	596
Number of species	6	6	2	3	3	4	3	3	2	4	1	2	1	3	2	2	2	2	3	5	3	1	2	3	4

Appendix Table 6–*1*. Appendicularians of the Transpac Expedition.

Stations	TP 59 A	TP 61	TP 67	TP 68	TP 69	TP 70	TP 71	TP 72	TP 73	TP 74	TP 76	TP 78	TP 79	TP 80	TP 80′	TP 81	TP 82	TP 83	TP 84	TP 85	TP 89	TP 92 A	TP 93	TP 94	TP 95
Oik. longicauda	9	10	38	28	266	58	71	24	36	132	307	942	198	23	6	38	52	31	6	47	44	98	139	51	197
Oik. intermedia											1														
Oik. fusiformis	10				311	18	36			6	75	146	163	8	1	29	80	37	10	29	23	38	44	44	40
Oik fusiformis f. *cornutogastra*													2							4			1		8
Oik. gracilis																									2
Oik. graciloides													2			1			2	1			3		
Oik. dioica						2	2		21			3	9				4						7	20	
Oik. rufescens						7					15	16	17	10		3	8	5		6	9	11	22		50
Oik. parva																									
Oik. cophocerca						1					1							1			1		3		14
Oik. albicans																									
Oik. labradoriensis		5	5	1					2																
Oikopleura spp. Damaged specimens or juv.	3				9	1	5	8	3	1	8	31	10	8	19	19	14	31	8	10	9	12	7	7	69
Meg. huxleyi						1											2	3		1	1	3	2		5
Steg. magnum													5		1	1	9	3		9	2			1	4
Alth. tumida																									
Frit. haplostoma						3							3			1	6	1		1				1	
Frit. abjornseni													1							1					
Frit. aberrans																									
Frit. formica f. *digitata*						5				2		6	1			2		1		1	3	2	4	2	13
Frit. pacifica																									
Frit. pellucida						1				9	3		5						2	3			1		1
Frit. borealis f. *typica*	52										1	1	1	2											
Frit. borealis f. *sargassi* Larger individuals					—	—				—	—	2	3	—		3	1	1	3	—	1		—	—	7
Smaller individuals					2	3				1	14	—	32	3		6	4	11	29	9	8		14	9	
Frit. megachile																									
Fritillaria spp. Damaged specimens or juv.													2	1				1							2
Tect. fertilis						11					5						1							1	3
App. sicula										1	1		3					1				13	1	1	
Kow. tenuis											2														
Total number	74	15	43	29	588	111	114	32	62	152	433	1147	457	55	27	103	181	127	60	122	101	177	248	137	415
Number of species	3	2	2	2	3	11	3	1	3	6	11	7	14	5	3	8	9	11	5	12	8	6	12	9	12

Appendix Table 6–2. Appendicularians of the Transpac Expedition.

Stations	TP 96	TP 97	TP 98	TP 99	TP 99′	Entrance to Yokosuka	TP 100	TP 101	TP 102	TP 103	TP 104	TP 105	TP 106	TP 107	TP 108	TP 109	TP 111	TP 112	TP 113	TP 114	TP 114′	TP 115	TP 116	TP 117	TP 118
Oik. longicauda	30	75	13	123	141		57	31	179	7	32	42	68	3	48	92	21		9	2	7	10	15	1	53
Oik. intermedia																			4						
Oik. fusiformis	8	19	20	44	31		13	9	69	7	9	12	3		1	11	10	24	39	3	1	10	2	18	7
Oik. fusiformis f. *cornutogastra*				1	1																				
Oik. gracilis																									
Oik. graciloides			4					2	6	1	2	2					1								
Oik. dioica	3	2				8			1				2		4	2			1			1		3	7
Oik. rufescens		7	2	31	10		10	5	30	2	5		3		16	30	2		6	2	3	3			7
Oik. parva																									1
Oik. cophocerca				4			3										1		1				2		
Oik. albicans									1		1														
Oik. labradoriensis																									
Oikopleura spp. Damaged specimens or juv.	5	7	2	11	139		18	8	23	8	30	2	17		3	4	5	2		1	2	8		6	7
Meg. huxleyi		3			2				2		1														
Steg. magnum		2		5			2	2	7						1	1									2
Alth. tumida							1																		
Frit. haplostoma				2	1		1																		
Frit. abjornseni																									
Frit. aberrans																									
Frit. formica f. *digitata*	3			4	1		1						2											1	
Frit. pacifica																									
Frit. pellucida				1	1				2		2														
Frit. borealis f. *typica*				2																					
Frit. borealis f. *sargassi* Larger individuals	—	1	—	—	4		1	—	—		—		—		—	—	—	—	—	—			—		—
Smaller individuals	9	—	1	12			12	4	22		4		3		4	8	1	1	3	1			1		2
Frit. megachile																									
Fritillaria spp. Damaged specimens or juv.				1	1											1								1	
Tect. fertilis				2			1		2			1	3		1	4								2	2
App. sicula		1		2			1						3		1	4	1								2
Kow. tenuis																									
Total number	58	117	42	245	332	8	121	61	344	25	86	59	104	3	79	157	42	27	63	9	13	32	20	32	90
Number of species	5	8	5	13	9	1	11	6	11	4	8	4	8	1	8	8	7	2	7	4	3	4	4	5	9

Appendix Table 6–3. Appendicularians of the Transpac Expedition.

Stations	TP 119	TP 120	TP 121	TP 122	TP 123	TP 124	TP 125	near Midway	TP 126	TP 127	TP 128	TP 129	TP 130	TP 131	*TP131B	TP 132	TP 133	TP 134	TP 135	TP 137	TP 141	*ST 89	F. O.	Mean percentage
Oik. longicauda	13		3	1					1	1	2		1	1	20	6	1	1	13	6	3	2	87	44
Oik. intermedia																							2	3
Oik. fusiformis	4	1	1	1	1	7	9		4	2	8	7	1	2	5	9	4	6	9	5			80	26
Oik. fusiformis f. *cornutogastra*																							7	*
Oik. gracilis																	1	1	2				4	4
Oik. gracilioides	1	1	2						1	2	1		1			2		2		2			24	5
Oik. dioica																							24	10
Oik. rufescens	2				4	6	6		9		8	1			4	4	1	1	1	12	1		48	11
Oik. parva				1		3														1			4	6
Oik. cophocerca	6			1	1	4			2	2	4	1	1	1	2	1				2	1		29	6
Oik. albicans	3	1		2		6			10						9								10	12
Oik. labradoriensis																							12	31
Oikopleura spp. Damaged specimens or juv.	6	1	3	1		6	1	1	1	3	2	5	8	7	36	12	4	2	12	30	3	1	84	12
Meg. huxleyi															1					?1			16	1
Steg. magnum		1				8	3		2	2	2				1		1	2		8			29	5
Alth. tumida																							1	1
Frit. haplostoma										1	2	1					2			31			16	5
Frit. abjornseni																							2	1
Frit. aberrans															3								1	4
Frit. formica f. *digitata*	1								2		2				1	2	2	2					27	3
Frit. pacifica															1								1	1
Frit. pellucida									1	2					1			2	3				22	7
Frit. borealis f. *typica*	?2																						18	14
Frit. borealis f. *sargassi* Larger individuals	—		—			—			3	—	—	—	—	1		1		2	—	—			61	10
Smaller individuals	1		1			3			4	3	1	1	7	—		6		2	9	11				
Frit. megachile													3										2	8
Fritillaria spp. Damaged specimens or juv.									1						1	1	1	3	4	7			18	3
Tect. fertilis																			1				17	2
App. sicula	1	1																					21	3
Kow. tenuis																							1	*
Total number	40	6	10	7	6	43	19	1	41	18	32	16	22	12	85	44	17	26	54	116	8	3	F.O. ··· Frequency of Occurrence	
Number of species	10	5	4	5	3	7	3		10	8	9	5	6	4	11	7	7	9	7	10	3	1	* ··· less than 0.5%	

*TP 131 B large net hauled from 450 m. *ST 89 Stranger: North Pacific 5509–2nd, 23.00.

Appendix Table 6–*4*. Appendicularians of the Transpac Expedition.

7—1

Stations	TP 1	TP 3	TP 4	TP 10	TP 12	TP 13	TP 14	TP 16	TP 17	TP 59A	TP 69	TP 70	TP 74	TP 76	TP 78	TP 79	TP 80	TP 81	TP 82	TP 83	TP 84	TP 85	TP 89	TP 92A	TP 93
Pyrosoma atlanticum atlanticum small colonies																						1			
Cyclosalpa floridana																									
Brooksia rostrata														g. 19											
Salpa cylindrica																g. 1				g. 3	g. 1				
Thalia democratica sol. sol. var. *orientalis*	— — g. 5		— — g. 7											— — g. 24			1 — g. 1	— 1 —	— — g. 2				— — g. 1		
Doliolum denticulatum														5		2			1	3		1			2
Doliolum nationalis											6	1	58	46	59										
Dolioletta gegenbauri var. *tritonis*	416						5	5	7	2			1	19	2							3			3
Doliolina spp.	2	418		12	4									9		1			1						2
Doliolid Amme	98	53				5	4	2	1	1					2			1					1	1	
Doliolid trophozooid	29	1				7	9	5	1															1	1
Doliolids, damaged individuals or juv.	24	40						5						3			1								

7—2

Stations	TP 94	TP 95	TP 97	TP 99	TP 99'	TP 100	TP 101	TP 102	TP 105	TP 106	TP 108	TP 109	TP 113	TP 115	TP 116	TP 117	TP 118	TP 120	TP 124	TP 125	TP 128	TP 131B	TP 134	F.O.
Pyrosoma atlanticum atlanticum small colonies																						4		2
Cyclosalpa floridana																		g. 1						1
Brooksia rostrata																								1
Salpa cylindrica				s. 1				g. 9																5
Thalia democratica sol. sol. var. *orientalis*	— 1 —	+ — g. +	— — g. 1	— — g. 9	— — g. 1		— 1 —	— — g. 10	— 1 —					— 2 g. 2		1 2 g. 24	— — g. 10	— — g. 1	1 — —	— — g. 1	— — g. 1	1 3 —		24
Doliolum denticulatum		14	1		7	3			1		1	1	1		1								1	16
Doliolum nationalis																								5
Dolioletta gegenbauri var. *tritonis*											? 2	1												12
Doliolina spp.	2		1	1								2												12
Doliolid Amme						2			1	1		1												15
Doliolid trophozooid	1					5			2			1									C			13
Doliolids, damaged individuals or juv.			1																					6

C.···common, g.···aggregated form, s.···solitary form, +···present

F.O.···Frequency of Occurrence

Appendix Table 7 (*1–2*). Thaliaceans of the Transpac Expedition.

Stations	MP 1			MP 2		MP 3									MP 5			MP 7		MP 8				MP 10						
	J 1	J 2	J 3	J 4	J 6	J 7	J 8	J 9	J 10	J 11	J 12	J 13	J 14	J 15	J 16	J 18	J 21	J 23	J 25	J 26	J 28	J 30	J 30	J 32	J 33	J 34	J 35	J 37	J 38	J 39
Oik. longicauda	167	377	62	11	22	1		17	17			6	1	4				2		8					3		54	55	13	22
Oik. intermedia			2															1												
Oik. fusiformis	4	23	4	2	1	29	13	36	83			1	1	2				1									40	1	1	2
Oik. fusiformis f. *cornutogastra*	—							1	1																					
Oik. graciloides	1	7	3					1																						
Oik. dioica				1																										
Oik. rufescens	2	19	2	2	2	59	48	22	27			2								1				3	3	9	16			
Oik. parva																											4			
Oik. cophocerca	30	53	5	14	2					1								1						1	1		10		2	2
Oik. albicans			3									5		2																
Oikopleura spp. Damaged specimens or juv.	157	163	58	1	3	28	25	125	71	1		15	7				1	5	9	157		1	2	1	3	5	107	297	69	50
Meg. huxleyi			1															2	6	3				2						
Meg. abyssorum																									1					
Steg. magnum								1	1				1	2				2	2	24										
Alth. tumida			?1																											
Frit. haplostoma		1							3											1										
Frit. aberrans													1						1											
Frit. formica f. *digitata*	16	21						18	8			1																	3	
Frit. fraudax																													1	
Frit. gracilis		1																									2			
Frit. pellucida	1	9								1																	1			
Frit. borealis f. *sargassi* Larger individuals	—	2	—			—	—	—	1			—	—														1	—	—	
Smaller individuals	3	—	4			4	7	63	486			1	1														2	1	1	
Frit. megachile																														
Frit. tenella										1																				
Frit. venusta																														
Fritillaria spp. Damaged specimens or juv.																													2	
Tec. fertilis																														
App. sicula		1							1																					
Total Number	381	677	145	31	30	121	93	284	699	4	0	31	12	10	0	0	1	14	18	194	0	1	2	7	11	14	237	354	92	76
Number of species	8	11	10	5	4	4	3	8	9	3	—	6	5	4	—	—	—	6	3	5	—	—	—	3	4	1	8	3	6	3

Appendix Table 8–*1*. Appendicularians of the Midpac Expedition.

Stations	MP 12					MP 14	MP 15	MP 16		MP 17		MP 18				MP 20						MP 35	MP 36		MP 41		F. O.	Mean percentage
	J 40	J 41	J 42	J 43	J 44	J 46	J 47	J 48	J 50	J 51	J 52	J 55	J 56	J 57	J 57	J 62	J 64	J 64	J 65	J 66	J 67	J 69	J 70	J 71	J 73	J 74		
Oik. longicauda	22	1		3	64	13	46					14	1	2	50	6		23	59	16	30	8	14	10	7	4	67	27
Oik. intermedia							4														1	1	1				11	3
Oik. fusiformis	6				1		32					2			10	8		10	53	29	1	8	4	7	2		54	9
Oik. fusiformis f. *cornutogastra*															1					1						1	9	1
Oik. gaciloides															7												9	1
Oik. dioica							5																				4	3
Oik. rufescens	3				13	7	21			1					14			2	16	12	1	1	3	4	4	3	53	13
Oik. parva							1								3			1									7	1
Oik, cophocerca					2	3	29	1				1		1	12	6		5	19	4	1	14	3	1	1		49	12
Oik. albicans							2								1						1						11	7
Oikopleura spp. Damaged specimens or juv.	15	1		2	28	17	38			2		7	2	27	103	22	4	34	43	65	45	16	12	25	54	13	82	45
Meg. huxleyi					1	11	1								2			1	5	1	1			1			25	8
Meg. abyssorum																											2	9
Steg. magnum					?1	2	5							2				3	14	4		1	3	2		1	32	6
Alth. tumida																											2	1
Frit. haplostoma							14								7			2	1	2	1						16	2
Frit. aberrans																											4	7
Frit. formica f. *digitata*					1		3								2					3			1		4		21	3
Frit. fraudax														?2	1			1		1				1	1		12	2
Frit. gracilis																			1								5	*
Frit. pellucida							9								1	1		2	4			1	2	2	11	1	25	4
Frit. borealis f. *sargassi* Larger individuals / Smaller individuals	— 1						8			— 1		— 1		?1	6	17 —	1	7	10	8		4 4	— 2	18 2	3 6	— 4	49	10
Frit. megachile																										1	2	3
Frit. tenella					1													2		2							7	7
Frit. venusta					3																						2	3
Fritillaria spp. Damaged specimens or juv.					2					1				1	5			3	1	4	2		2	1		3	21	4
Tec. fertilis							1																				2	*
App. sicula																											4	*
Total number	47	2	0	5	117	53	219	1	0	5	0	25	3	36	225	60	5	96	226	152	84	58	47	74	93	31	F.O.···Frequency of Occurrence *···less than 0.5	
Number of species	4	1	—	1	9	5	15	1	—	2	—	4	1	5	14	5	1	12	10	12	8	8	9	9	8	7		

Appendix Table 8-*2*. Appendicularians of the Midpac Expedition.

9—*1*

Stations	MP 1		MP 2		MP 3				MP 5			MP 7		MP 8				MP 10				
	J 1	J 3	J 4	J 6	J 11	J 12	J 13	J 14	J 16	J 18	J 21	J 23	J 25	J 26	J 28	J 30	J 30	J 32	J 33	J 34	J 35	J 38
Pyrosoma atlanticum atlanticum small colonies										2		3		1	2	18	33		3			
Cyclosalpa pinnata																g. 1						
Cyclosalpa strongyrenteron															g. 17							
Cyclosalpa sp.																s. 1						
Brooksia rostrata																						
Ritteriella amboinensis									? s. 1		s. 1	s. 2					s. 1					
Metcalfina hexagona											g. 1	g. 8	s. 2									
Salpa fusiformis				+														g. 2				
Salpa cylindrica			s.3, g.6	+																		
Ihlea sp.										? s. 1												
Iasis zonaria											g. 5	g. 10		g. 3	s.2, g.15	g. 7	g. 1					
Thalia democratica sol. sol. var. *orientalis*				1 — —							— 1 —					— 1 —		— 3 —	1 33 —	— 10 —		— 2 —
Pegea confoederata																			1			
Doliolum denticulatum		3																8			1	2
Doliolina intermedia												5	4	6	1	14	1					
Doliolina spp.			9	1																	1	
Doliolid Amme	2	12	81	6	7	1	1	3		3	3	15	10	5		15	6		2		3	
Doliolid trophozooid																						
Doliolids, damaged individuals or juv.																	2					1

9—*2*

Stations	MP 12			MP 14	MP 15	MP 16		MP 18			MP 20					MP 35	MP 36		MP 41	F. O.
	J 40	J 41	J 44	J 46	J 47	J 48	J 50	J 55	J 57	J 57	J 62	J 64	J 65	J 66	J 67	J 69	J 70	J 71	J 73	
Pyrosoma atlanticum atlanticum small colonies							3													14
Cyclosalpa pinnata				s.2, g.6			g. 1													5
Cyclosalpa strongyrenteron																				2
Cyclosalpa sp.																				2
Brooksia rostrata				s. 5														g. 1		4
Ritteriella amboinensis				s. 56		s. 180, g. 134	s.15, g.4				s. 1									14
Metcalfina haxagona																				2
Salpa fusiformis																				4
Salpa cylindrica				s.8, g.9																5
Ihlea sp.																				2
Iasis zonaria				s.2, g.21		g. 22														14
Thalia democratica sol. sol. var. *orientalis*				— 14 —		4 2 —	2 5 —	— 1 —	— 1 —	1 5 —		— 2 —	— 1 —	— 3 —	2 — —			— 1 —	— 1 —	34
Pegea confoederata																				2
Doliolum denticulatum	4	1			7									1	1	1				18
Doliolina intermedia																				10
Doliolina spp.																		1		7
Doliolid Amme			1	149	5	2			1			6	16	5	4	3	2	12	3	54
Doliolid trophozooid														2						2
Doliolids, damaged individuals or juv.																				4

g.···aggregated from, s.···solitary form, +···present. F.O.···Frequency of Occurrence

Appendix Table 9 (*1–2*). Thaliaceans of the Midpac Expedition.

10

Stations	EQP S28	EQP H3	EQP H7	EQP H11	EQP H17	F.O.	Mean percentage
Oik. longicauda	354	19	5	414	64	100	22
Oik. intermedia				3	15	40	1
Oik. fusiformis	40	14	3	88	38	100	7
Oik. fusiformis f. *cornutogastra*					1	20	*
Oik. graciloides		1			1	40	1
Oik. rufescens	20	3	2	44	131	100	7
Oik. cophocerca	3	3		3	32	80	2
Oik. albicans				5		20	1
Oikopleura spp. Damaged specimens or juv.	75	11	61	356	139	100	26
Meg. huxleyi		1	5	9	11	80	2
Steg. magnum			1	22	44	60	3
Pelagopleura sp.				1	1	40	*
Alth. tumida	1					20	*
Bathochordaeus sp. tail					1	20	*
Frit. haplostoma	1		1			40	1
Frit. aberrans	2					20	*
Frit. formica f. *digitata*	9	2		5	4	80	1
Frit. fraudax	11				2	40	1
Frit. gracilis	1	3				40	1
Frit. pacifica	1				25	40	2
Frit. pellucida	124	73	23		15	80	23
Frit. borealis f. *intermedia*	1					20	*
Frit. borealis f. *sargassi* Larger individuals Smaller individuals	36	— 1	2 6		22	80	4
Frit. megachile	1		1			40	1
Frit. tenella	246	1		5	19	80	8
Frit. venusta	23		2	1	25	80	2
Fritillaria spp. Damaged specimens or juv.	10		2	1	5	80	1
Tec. fertilis					9	20	1
Total number	959	132	114	957	604		
Number of species	17	11	10	12	19		

F.O.···Frequency of Occurrence

Appendix Table 10. Appendicularians of the Equapac Expedition.

11

Stations	EQP S28	EQP H3	EQP H7	EQP H11	EQP H17	F.O.
Pyrosoma atlanticum atlanticum small colonies				9	1	40
Pyrosoma verticillatum				3		20
Cyclosalpa bakeri			g. 2			20
Salpa maxima	s. 2			g. 6		40
Salpa fusiformis		s. 2 g. 8			g. 1	40
Salpa cylindrica		s. 1 g. 2		s. 1 g. 3		40
Iasis zonaria				g. 1		20
Thalia democratica sol. sol. var. *orientalis*	— 1 g. 2	3 — g. 7		— — g. 3	4 10 g. 46	80
Traustedtia multitentaculata					g. 1	20
Doliolum denticulatum			1	19	11	60
Doliolina undulata					1	20
Doliolid Amme	2	3	7	17	25	100
Doliolids, damaged individuals or juv.				1		20
Doliopsis rubescens					1	20

g.···aggregated form, s.···solitary form

Appendix Table 11. Thaliaceans of the Equapac Expedition.

12

Stations	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	26	27	28	29	F.O.
Pyrosoma atlanticum atlanticum small colonies						1											2												7
Cyclosalpa pinnata	g. 1*			s. 1 g. 1	g. 2*	s. 1 g. 5*	g. 2		g. 1										g. 1*										25
Cyclosalpa affinis					g. 5																		g. 6						7
Cyclosalpa floridana			g. 1																										4
Cyclosalpa sp.																											s. 1		4
Brooksia rostrata									s. 1		g. 1																s. 6		11
Ritteriella sp.																											s. 2		4
Salpa fusiformis		g. 1			s. 2								g. 6								g. 2								14
Salpa cylindrica		g. 1	g. 1			s. 1	g. 12		g. 4		g. 5	s. 1 g. 2	s. 4 g. 10						g. 1					s. 2 g. 5	s. 1 g. 3				39
Ihlea asymmetrica													g. 2																4
Iasis zonaria														g. 1												g. 2			7
Thetys vagina																										g. 1			4
Thalia democratica sol. sol. var. *orientalis*	2 — g. 22	2 — —	— — g. 7		— 1 g. 4	— 5 g. 12	— 13 g. 8	— 5 g. 5	— 2 g. 5	— 14 g. 23	3 — g. 9	2 — g. 11	— — g. 5	— 2 g. 25		— — g. 8	— 5 g. 2			— — g. 3	— 1 —	— — g. 1		1 3 g. 15	— 1 g. 9	— 13 g. 51	22 1 g. 29	1 4 g. 5	25 50 75	82
Pegea confoederata					s. 3									g. 3															7
Traustedtia multitentaculata			s. 1																										4
Traustedtia multitentaculata var. *bicristata*			s. 1																										4
Doliolum denticulatum	1	39	2			2					7	4	1														8	3	32
Doliolid Amme	16	25	5		1	1	3	11	3	8	33	32	1	7		2	7			4	10	8				1	20	35	75
Doliopsis rubescens							1				6																		7

* var. *polae*

Appendix Table 12. Thaliaceans collected by the Syunkotu-maru in the Central Pacific.

13

Stations	4	6	7	9	10	11	18	19	28	34	35	37	40	41	42	45	46	48	49	51	54	55	56	F.O.
Cyclosalpa pinnata														g. 5										2
Thalia democratica var. *orientalis*	s. 1 —														— 9									4
Doliolum denticulatum	1			2	1	2	1	1	1											1				15
Dolioletta gegenbauri	1	2	2							1	11	1		5	3		1	1	1	1	1		1	25
Doliolina sp.	1			4	3	5																		7
Doliolid Amme				1		1					2					1		5				1		11
Doliolid trophozooid											1		3					1						5

Appendix Table 13. Thaliaceans from the Arafura Sea.

14

Stations	22	24	33	34	35	38	40	F.O.
Doliolum nationalis				1		1	1	12
Doliolina sp.	?2			1				8
Doliolids, damaged specimens or juv.				2	1			8
Doliolid Amme			1	1				8
Doliolid trophozooid		1		1				8

Appendix Table 14. Thaliaceans from the central part of the tropical Indian Ocean.

F.O.···Frequency of Occurrence
g.···aggregated form
s.···solitary form

15—*1*

Stations	Division O						Ryûgû Inlet										Division P						Division L							Arumizu		
	25/V	15/VI	3/VII	14/VIII	10/IX	25/X	18/V	28/V	3/VII	6/VIII	30/VIII	27/IX	25/X	Pool 18/V	red water 28/V	next inlet 6/VI	21/V	3/VI	22/VII	30/VIII	17/IX	25/X	15/V	15/V	31/V	(east) 30/VII	22/VIII	27/IX	25/X	13/V	21/V	3/VI
Doliolum denticulatum																																
Dolioletta gegenbauri var. *tritonis*											○							○		○			C	C								○
Doliolid Amme																				○			○	○								
Doliolid trophozooid																				○			○	○								
Oik. longicauda	○	C	○	C	○	○	C	C	○	C	C	○	○	C	○	○	○	○	C	C	○	C	C C	C C	○	○	C	○	C	C	C	C
Oik. fusiformis	○																															
Oik. fusiformis f. *cornutogastra*			○	○	○	○	○	○	○	○	C	○	○	○		○	○	○	○	C C	○	C	○	○	○	○	○	○	○	○	○	○
Oik. dioica	○	○	○	○		○	C	○	○	○	○		○	○		C	○	○	○	○	○	○	○	○	○	○	○		○		○	○
Oik. rufescens			○	○	○	○				C	○	○							○	○		○	○	○		○	○	○	○	○		
Oik. cophocerca																																
Steg. magnum																																
Frit. haplostoma		○	○	○		○	○	○		○	○		○				○	○		○		○	C	○		○					○	○
Frit. abjornseni																							○									
Frit. formica f. *digitata*																																
Frit. pellucida																																
Frit. borealis f. *sargassi* Larger individuals			—													—	—	—	—					○	—						—	
Smaller individuals			○													○	○	○	○						○						○	
Fritillaria sp. Damaged specimen																																
App. sicula	○	○	○	○			○		○		○		○			○	○	C C	○	○			○	○	C		○			○	○	○

15—*2*

Stations	Arumizu (continued)						Arappu					Arakabesan						Anchorage							Oropusyakaru Bay		Gasupan Bay	off Aruma-tenguru	West Lagoon off Gasupan	South of Uruku-taberu	F.O.
	27/VI	22/VII	14/VIII	17/IX	25/X	S. Inlet 27/VI	13/V	21/V	30/VII	25/X	Grotto 13/V	18/V	31/V	15/VI	6/VIII	10/IX	27/X	15/V	25/V	6/VI	22/VII	33/VIII	17/IX	27/X	N.W. Inlet	inner-most St.					
Doliolum denticulatum			○																												2
Dolioletta gegenbauri var. *tritonis*			○		○								○	○	○		○	○		○	○										24
Doliolid Amme			○												○																8
Doliolid trophozooid			○																												6
Oik. longicauda	C	C	C	○	C	○	○	○	C C	○	○	C	C	○	C	○	C	C	C C	C	C C	C	○	○	C	○			C	○	97
Oik. fusiformis																															2
Oik. fusiformis f. *cornutogastra*	○	C	○	○	○		○	○	C	○		C	C	C	○	○	C	○	○	○	C	C	○	C	○	○			○		87
Oik. dioica		○	○			○	○	○	○	○	○	○		○		○	○	○	○	C	○	○	○	○	○	C	○		○		81
Oik. rufescens		○	○	○	C				○	○		○	○	○	○	○	○	○		○	C	C	○	○					○		58
Oik. cophocerca																													○		2
Steg. magnum																	○							○							3
Frit. haplostoma		○	○	○	○		C		C C	○		○	○	○		○		○	C	○	C	○			○	○			○		60
Frit. abjornseni							○											○													5
Frit. formica f. *digitata*																				○											2
Frit. pellucida							○		○														○						○		6
Frit. borealis f. *sargassi* Larger individuals		—			—		—		○				—	—			—	—	—	—									—		32
Smaller individuals		C			○		○		○				○	○			○	○	○										○	○	
Fritillaria sp. Damaged specimen											○																				2
App. sicula		○	○		○		○	○	○	○		○	○	○	○		○	○	○	○	○	○		○	○	○			○		66

C···common, CC···very common

F.O.···Frequency of Occurrence

Appendix Table 15 (*1–2*). Pelagic tunicates occurred in Iwayama Bay, Palao.

Stations	North Equatorial Current																									
	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	59	60	61	62	63	64
Brooksia rostrata																										
Salpa cylindrica																										
Thalia democratica sol. sol. var. *orientalis*							— — g. ○				— ○ —			— ○ ○				— ○ —								
Doliolum denticulatum	○					○	○	○	○	○			○	○	○			○	○							○
Doliolum nationalis															○	○										
Dolioletta gegenbauri var. *tritonis*						○										○	○									
Doliolina spp.										○																
Doliolids, damaged specimens or juv.										○	○															
Doliolid Amme						○				C	○		○	○		○									○	
Doliolid trophozooid										○																○
Oik. longicauda	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		○	○				
Oik. intermedia																										
Oik. fusiformis	○	○	C	○	C	○	○	○	○	○	○	○	○		○				○	○	○	○	○		○	
Oik. fusiformis f. *cornutogastra*										○			○	○	○	○	○		○					○		○
Oik. graciloides																○										
Oik. dioica								○		○																
Oik. rufescens		○	○	○	○	○	○	○	○	○	○	○	○	○	○	C	○	○	○	○	○	○	○	○	○	○
Oik. cophocerca	○	○		○			○		○	○	○	○	○	○	○	○	○	○	○	○	○	○				
Oikopleura spp. Damaged specimens or juv.																	○									
Meg. huxleyi	○	○	○	○				○		○	○	○			○	○	○	○	○	○						
Steg. magnum	○	○	○	○	○	○	○		○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		○	○
Pel. verticalis						○	?○										?○					?○				
Frit. haplostoma	○	○	C	○	○	○					○	○	○	○	○		○	○	○				○	○		○
Frit. abjornseni		?○											○	○						?○					?○	
Frit. formica f. *digitata*	○	○	○	○	○	○	○		○	○	○	○	○	○	○	○	○		○	○				○		○
Frit. gracilis																○		○	○	○						
Frit. pellucida	○	○	○	○	○					○	○	○	○	○	○	○	○	○	○						○	○
Frit. borealis f. *intermedia*		?○																								
Frit.borealis f. *sargassi* Larger individuals Smaller individuals	— ○		— ○	— ○	○ —	○ ○	— ○	○	○ ○	○ ○	○ ○	○ ○	○ ○	○ ○	○ ○	○ ○	○ ○	○ ○	○ ○	○ ○	○ —	— ○	— ○	— ○	— ○	○ —
Frit. venusta																										
Tec. fertilis											○															
Kow. tenuis																										
App. sicula			○																○							
Number of species*	9	11	10	10	8	8	8	6	7	11	11	10	11	10	11	11	11	9	13	10	6	7	5	5	6	7

* of Appendicularians C···common ,g.···aggregated form

Appendix Table 16–*1*. Pelagic tunicates occurred in the neighbouring waters of the Palao Islands.

Stations	North Equatorial Current														Counter Equatorial Current								South Equatorial Current		F.O.
	65	66	67	68	69	70	71	72	73	74	75	76	14	15	77	78	79	80	83	84	85	86	81	82	
Brooksia rostrata													g.	g.						g.				s.	8
Salpa cylindrica																		g.							2
Thalia democratica sol. sol. var. *orientalis*		— — g. ○				○ — —					○ — —	— — g. ○	— — g. ○	○ ○ g. ○		— — g. ○		— — g. ○			— — g. ○			— — g. ○	28
Doliolum denticulatum													○	○	○		○	○	○	○			○	○	42
Doliolum nationalis																									4
Dolioletta gegenbauri var. *tritonis*									?○							○		○	○	○	○		○	○	22
Doliolina spp.															○		○	?○		○				?○	12
Doliolids, damaged specimens or juv.																									2
Doliolid Amme													○	○			○	○	○	○		○			28
Doliolid trophozooid												○						○		○					6
Oik. longicauda	○	○											○	○	C C	C	C C	C	○	○	○	○	○	○	70
Oik. intermedia																○	○	○							2
Oik. fusiformis	○		○	○	○	○	○	○	○		○	○						○	○	○	○		○		70
Oik. fusiformis f. *cornutogastra*		○								○			○	○	○	○	○		○			○		○	38
Oik. graciloides														○			○								6
Oik. dioica																		○		○			○	○	12
Oik. rufescens	○	○			○		○	○	○			○	○	○	○	○	○	○	○	○	○	○	○	○	88
Oik. cophocerca	○	○						○			○				○	○	○	○	○	○	○	○	○	○	64
Oikopleura spp. Damaged specimens or juv.																									2
Meg. huxleyi														○	C	○		○		○	○	○	○	○	46
Steg. magnum		○		○			○		○	○			○	○	○	○	○	○	○	○	○	○	○	○	82
Pel. verticalis																	○	○			○				14
Frit. haplostoma	○	○	○	○				○	○	○	○		○		○	○		○	○	○		○			66
Frit. abjornseni																									10
Frit. formica f. *digitata*	○	○	○				○						○		○	○	○	○	○	○		○	○	○	68
Frit. gracilis																									8
Frit. pellucida	○	○	○	○	○	○	○				○			○	○	○		○	○	○					62
Frit. borealis f. *intermedia*																									2
Frit borealis f. *sargassi* Larger individuals Smaller individuals	— ○	— ○		— ○			— ○	— ○	— ○	— ○	— ○	— ○	— ○	○ ○	— ○	— ○	○ —	○ ○	— ○	— ○	— ○	— ○	— ○	— ○	92
Frit. venusta																		○							2
Tec. fertilis														○								○			6
Kow. tenuis																				○					2
App. sicula																	○	○					○	○	12
Number of species*	8	9	4	5	3	2	6	5	5	4	5	3	7	9	10	11	11	15	10	12	8	10	10	10	F.O.···Frequency of Occurrence

* of Appendicularians C···common, CC···very common, g.···aggregated form, s.···solitary form

Appendix Table 16–*2*. Pelagic tunicates occurred in the neighbouring waters of the Palao Islands.

(C···common, CC··· very common, g.···aggregated form, s.··· solitary form)

Stations	North Equatorial Current						Counter Equatorial Current											South Equatorial Current														F.O. (%)
	1	2	3	4	52	53	5	6	7	8	54	55	56	57	58	59	60	9	10	11	12	13	14	15	61	62	63	64	65	66	67	
Brooksia rostrata							s.										g.	s.														6
Salpa cylindrica								s.	s.								g.				g.											13
Thalia democratica					g.		○		s.		g.	g.				g.		g.		s.								g.	g.	g.		35
Doliolum denticulatum	○				○	○	○	○	○	○	○	○	○	○	○			○	○	○		○		○		○	○	○	○	○	○	74
Doliolum nationalis																								○								3
Dolioletta gegenbauri var. *tritonis*									○										○	○			○						?○			16
Doliolina sp.										○										○												6
Doliolid Amme					○		○	○	○	○		○					○	○						○		○	○	○			39
Doliolid trophozooid																	1*							○			○	○		○	13
Oik. longicauda			○		○	○	C C	○	○	C	○	○	○	○	○	○	○	C	C C	C C	C	C	C	C C	○	○		○	○	○	○	87
Oik. intermedia										○																						3
Oik. fusiformis	○	○		○	○	○	○	○	○	○	○	?○	○		○	○	○	○	C	○	○	C	○	○	○	○	○	○	○	○	○	94
Oik. fusiformis f. *cornutogastra*																											?○		○			6
Oik. dioica					○		○	○										○				○		○					○			23
Oik. rufescens	○	○	○	○		C	○	○	○	○	○	○		○	○		○	C	○	C	○	○	○	C	○	○	○	○	○	○	○	90
Oik. cophocerca	○					○	○			○		○					○	○	○	○	○	○	○	○				○	○	○		52
Meg. huxleyi	○			○	○		○	○	○	○	○				○			○							○		○	○	○	○		48
Steg. magnum					○	○	○	○		○	○	○			○	○		○	○	○	○	○	○	○	○	○	○	○		○		68
Pel. verticalis										○	?○																					6
Frit. haplostoma	○			○		○	○	○	○	○	○							○	○	○			○	○	○	○	○	○	○		○	61
Frit. abjornseni					?○	○					○	○					○					○						○				19
Frit. aberrans					○	○					○																					10
Frit. formica f. *digitata*	○	○		○	○	C	○	○		○	○	○				○	○	C	○	○	○	○	○	○	○	○	○	○	○	○		81
Frit. fraudax											○	?○																				6
Frit. pellucida	○		○		○	○			○	○	○	○						○	○	○				○	○	○	○	○	○			55
Frit. borealis f. *sargassi* Larger individuals	○	○	○	○	○	○		○	○	○	○	○				—	○	○	—	—		—	—	○	—	○	○	○	○	○	—	84
Smaller individuals																○			○	○		○	○	—	○						○	
Frit. megachile																		?○														3
Frit. tenella										○																						3
Fritillaria spp. Damaged specimens or juv.										○																						3
Tec. fertilis											○																					3
Kow. tenuis										○																						3
App. sicula			○						○	○							○	○	○		○			○				○	○			32
Number of species*	8	4	5	6	9	11	9	9	8	15	14	10	2	2	5	5	8	13	10	9	7	9	8	11	9	8	9	12	12	8	5	F.O.···Frequency of Occurrence

* of Appendicularians

* *Doliopsis rubescens* (F.O.···3%)

Appendix Table 17. Pelagic tunicates occurred in samples collected during the Palao—New Guinea cruises, 1940.

Stations	J1	J2	J3	J4	J5	J6	J7	J8	J9	J10	J11	J12	J13	J14	J15	J16	J17	J18	J19	F.O.	Mean percentage
Brooksia rostrata					s. 1															5	
Thalia democratica sol. sol. var. *orientalis*						1 — —	— 1 —							1 — —				1 — —		16 5 — 21	
Doliolum denticulatum														1						5	
Doliolum nationalis	62					13	18		2		14	5							33	37	
Dolioletta gegenbauri var. *tritonis*						1	1					1	1							21	
Doliolina spp.					3	1						1								16	
Doliolid Amme												1								5	
Oik. longicauda	137	1	40	180	9	78	176	92	48	38	117	85	54	29	15	15	3	7	49	100	69
Oik. fusiformis	13			40		35	84	11	1		4	7	13	6	1	1	3		17	74	13
Oik. fusiformis f. *cornutogastra*				1								1				1				16	1
Oik. graciloides	1												1					1		16	2
Oik. dioica									1	1	1	7								21	3
Oik. rufescens					3	1	6				2	6	5	8	4			1	3	53	7
Oik. cophocerca														1						5	2
Oik. labradoriensis			2																	5	5
Oikopleura spp. Damaged specimens or juv.	2		1	4	8	1	4	3			1	5	3	2	3	1		3		74	6
Steg. magnum												1	1	1	1			1		26	3
Frit. haplostoma							2							1						11	2
Frit. arafoera												1								5	1
Frit. formica f. *digitata*						1	4						1			6	1	2		32	7
Frit. fraudax												1								5	1
Frit. pellucida	2					1					2			1					1	26	1
Frit. borealis f. *typica*									1											5	2
Frit. borealis f. *sargassi* Larger individuals Smaller individuals					— 4	6 1	— 1				— 5	— 8	3 —	3 2	— 1	1 8	— 4	— 2		58	11
Frit. megachile												2								5	2
Fritillaria spp. Damaged specimens or juv.							1											1		11	3
Tec. fertilis					1	7	8				1									21	3
App. sicula					1		3					1		1	1	1				32	3
Kow. tenuis							1													5	*
Total number	155	1	43	225	26	131	290	106	51	39	133	125	81	55	26	34	11	18	70	F.O.···Frequency of Occurrence	
Number of species	4	1	2	3	5	7	9	2	4	2	7	11	7	9	6	6	4	6	4	*···less than 0.5%	

s.···solitary form

Appendix Table 18. Pelagic tunicates occurred in samples from the North—Eastern waters of Japan.

Stations	More northern waters than 40°N.						Waters off north-eastern Honsyû, south to 40°N.						Sagami Bay						Waters off south-western Honsyû							
	20* (1934)	17 (1934)	15 (1934)	13 (1934)	13 (1937)	13 (1938)	11 (1934)	77 (1938)	77 (1939)	78 (1937)	9 (1938)	5 (1938)	11/Sept. (1934)	13/Dec. (1934)	F2 (1934)	A	B	C	near Niizima (1934)	2 (1938)	5 (1939)	7 (1938)	18 (1939)	23 (1938)	10 (1939)	29 (1938)	21 8/VI (1939)
Pyrosoma atlanticum atlanticum													4			1											
Pyrosoma atlanticum atlanticum Larval or small colonies							17						C C	C	C C		29	2	C			15			1		
Pyrosoma agassizi																											
Cyclosalpa pinnata											g. 1																
Cyclosalpa floridana																											
Brooksia rostrata																											
Metcalfina hexagona																											
Salpa maxima												g. 19															
Salpa fusiformis			g. 11			s. 2 g. 34*	s. 1 g. 6	g. 70*			g. 10				g. 2							s. 25 g. 38*				s. 6 g. 1	s. 7 g. 3
Salpa fusiformis f. *aspera*	s. 3 g. 13											s. 2												s. 8 g. 4			
Salpa cylindrica																											
Iasis zonaria							g. 1					g. 8	g. 3													g. 2	g. 1
Thetys vagina									s. 1 g. C																		
Thalia democratica				s. 1			s. 4 g. 7	s. 5 g. 9		s. 9 g. 14	s. 2		s. 2 g. 2	s. 6 g. 8	s. 10 g. 17	s. 1	g. 2	s. 1 g. 6	s. 2 g. 1			g. 1	s. 1 g. 2		s. C g. C		s. 2 g. 1
Pegea confoederata																											
Traustedtia multitentaculata																											
Doliolum denticulatum							2						6		5	2	7	11	8		21						1
Doliolum nationalis					4					14		2	1												1		
Dolioletta gegenbauri var. *tritonis*					11		13	2		6								1		4							
Doliolid Amme			1		5		4		3	23	2	2			1	3				1		3					
Doliolids, damaged individuals or juv.				+																							
Oik. longicauda		2	1	4	6		26			6		1	12		42	7	4	18	10	5		1					
Oik. fusiformis							1									22	1		10								
Oik. rufescens					4	1	11		1	51			5			1			2		1	1					
*Oik. parva**																1											
Oik. cophocerca																						1					
Oik. albicans													1														
Oik. labradoriensis		2																									
Oikopleura spp. Damaged specimens or juv.									4	1										1				1			
Meg. huxleyi							3				4	8															3
Steg. magnum																			2								
Frit. borealis f. *sargassi*																											

* Tail musculature wide as in *Oik. najadis*. * St. 20···42°N.×160°E. * a few of f. *aspera* included. g.···aggregated form, s.···solitary form, C···common, CC···very common, +···present

Appendix Table 19–*1*. Pelagic tunicates collected by the Sôyô-maru in the neighbouring waters of Japan.

g.···aggregated form, s.···solitary form, C···common, CC···very common, +···present, r···rare. F.O.·····Frequency of Occurrence

Stations	Waters off south-western Honsyû (continued)						Southern waters off Kyûsyû						East China Sea (1939)					Taiwan Straits (1939)		South China Sea (1939)							F.O.
	21 29/VIII (1939)	47 (1938)	48 (1938)	25 (1939)	72 (1938)	A	30 (1939)	103 (1938)	98 (1938)	84 (1938)	95 (1938)	52 (1938)	35 1/VI	35 13/VI	40	120	125	50	55	70	75	80	84	88	92	95	
Pyrosoma atlanticum atlanticum																											4
Pyrosoma atlanticum atlanticum Larval or small colonies																											17
Pyrosoma agassizi																									2		2
Cyclosalpa pinnata									s.1, g.2																		4
Cyclosalpa floridana							s. 1																				2
Brooksia rostrata																					s. 2						2
Metcalfina hexagona																									s. 1		2
Salpa maxima										s. 1 g. 5																	4
Salpa fusiformis		s. 3 g. 2									s. 1																21
Salpa fusiformis f. *aspera*																											6
Salpa cylindrica																				s. 4							2
Iasis zonaria		g. 5																s. 1 g. 9									13
Thetys vagina																											2
Thalia democratica		s. 1 g. 3	s. 6 g. 1	s. 21 g. 18			s. c g. r	g. 1	s. 3	s. 17	g. 1	s. g. } cc	s. g. } cc	s. g. } c		s. 13 g. 3	s. 1			s. 4	s. g. } cc						58
Pegea confoederata									g. 1											g. 1			s.1, g.8				6
Traustedtia multitentaculata												g. 1	? +														4
Doliolum denticulatum		1		94	1				3	2	1	1			3						C						34
Doliolum nationalis																											9
Dolioletta gegenbauri var. *tritonis*																					C						13
Doliolid Amme						1				1											1						26
Doliolids, damaged individuals or juv.																											2
Oik longicauda	11	1			1					2						38	4		r	1				7		31	47
Oik. fusiformis										1						17										7	13
Oik. rufescens	1		1	1		3								1		6	1		+		15+					8	38
*Oik. parva**																											2
Oik. cophocerca																											2
Oik. albicans																											2
Oik. labradoriensis																											2
Oikopleura spp. Damaged specimens or juv.												1				21	8			4						8	17
Meg. huxleyi					7					3	5					15				5	58	3			3		23
Steg. magnum																											2
Frit. borealis f. *sargassi*																2	1										4

* Tail musculature wide as in *Oik. najadis*.

Appendix Table 19–*2*. Pelagic tunicates collected by the Sôyô-maru in the neighbouring waters of Japan.