A STUDY ON THE ECHINOID FAUNA OF THE EAST CHINA SEA AND THE COASTAL WATERS OF SOUTHERN KOREA, KYUSHU, RYUKYU, AND TAIWAN

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With Text-figures 1–13 and Tables 1–9

Introduction

I have recently had chances to examine a large number of echinoid specimens collected from various localities which cover so wide a range as to enable a faunal or zoogeographical study of the East China Sea and its adjacent waters.

The topography and the marine environmental condition of the present region are as follows:

The East China Sea spreads from the Chinese coast eastward to southwestern Japan. There is Korea to the north, Kyushu to the east, Ryukyu to the southeast to south, and Taiwan to the southernmost. It connects with the Pacific Ocean through a chain of islands arranged in an arc, the Nansei-Shoto Group which includes the Ohsumi, the Amami, the Okinawa, the Miyako, and the Yaeyama Groups. The floor of the East China Sea is widely occupied in its western part by the Chinese continental shelf. Southeastwardly it deepens toward the Ryukyus forming a wide bathyal zone, called the Okinawa Trough, which reaches to ca. 2,500 m at its deepest point. On the Pacific side of the Ryukyus, the sea floor abruptly deepens to form the Ryukyu Trench which reaches to ca. 7,800 m at its deepest point (Fig. 1).

The ocean currents and water masses in the East China Sea and its adjacent waters are shown in Figure 2. Among the warm waters, the Kuroshio current is most prominent and dominates the oceanographical condition of the southern and southeastern part of the East China Sea. It flows from the east coast of Taiwan northeastward along the edge of the continental shelf. In the north of Amami-Ohshima Island (ca. 29°5′N., 129°E.), it leaves the edge of the continental shelf gradually, turning to the east, and finally flows out to the Pacific Ocean through the Tokara Strait. The axis of this current is stable and rarely undulates. It carries $20–60 \times 10^6 m^3$ water mass per second at the speed of 1.5–3.0 knot per hour; and its salinity is 34.0–34.5 ‰ (Inoue, 1974).

The Tsushima current, a large branch of the Kuroshio, begins at the point where the Kuroshio leaves the edge of the continental shelf. It flows at about 0.5–1.5 knot per hour northward in the area off western Kyushu and west of the Goto

Islands, and finally flows into the Japan Sea through the Tsushima- and Korea Straits. The axis of this current is stated to deviate somewhat between west and east, or undulates under the influence of the cold water mass of the Yellow Sea, the coastal water of the Chinese Continent, and the coastal water of Kyushu (Tsujita, 1957; Inoue, 1974; Ogawa *et al.*, 1978). The water of this current is mainly composed of the Kuroshio water and waters upwelled along the edge of the continental shelf

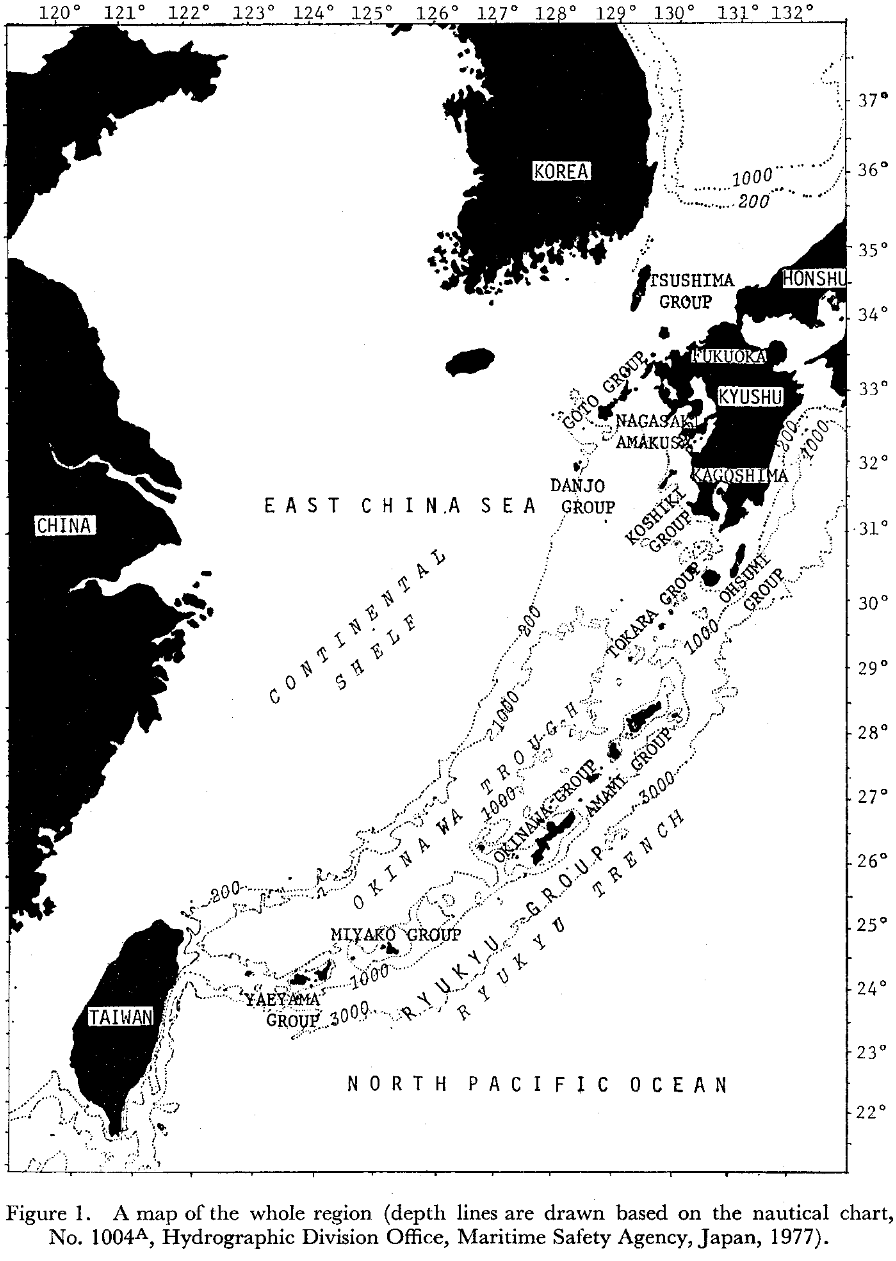

Figure 1. A map of the whole region (depth lines are drawn based on the nautical chart, No. 1004A, Hydrographic Division Office, Maritime Safety Agency, Japan, 1977).

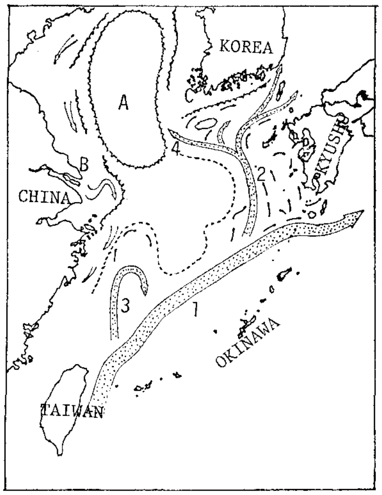

Figure 2. Currents and water masses in the East China Sea and its adjacent waters (modified from Inoue, N., 1974).
1–4, warm waters. A-C, cold waters. 1-Kuroshio current; 2-Tsushima current; 3-Median warm current; 4-Yellow Sea warm current; A-Cold water mass in the Yellow Sea; B-Coastal water of the Chinese Continent; C-Coastal water of the Korea Peninsula.

from depths of 50–200 m (Inoue 1974).

The median warm current is a branch of the Kuroshio and the Yellow Sea current is a branch of the Tsushima current. These branches are greatly influenced by the coastal waters of the Chinese Continent and the cold water mass of the Yellow Sea respectively, and seasonal variations of current conditions are fairly large.

There is a large, cold water mass in the Yellow Sea. The water temperature of the mass rises in early summer only up to 10–15°C (at a depth of 50 m). Seasonal variation of the surface temperature is stated to be 14–19°C (Kikuchi, 1968).

The coastal water of the Chinese Continent is also cold in winter and its salinity is very low. However, the water temperature and salinity are variable in different areas and different seasons, according to the condition of the subaerial climate of the Chinese Continent.

In winter, these cold water masses become particularly massive and spread widely toward the southeastern part of the continental shelf as far as the area of ca. 30°N., 127°E,. The seasonal, northwest wind takes part in this spreading.

The coastal water of southern part of the Korea Peninsula lies in the area north of a line drawn from off the northern coasts of Cheju Island to the Tsushima Islands. There occurs a distinct front between this water mass and the Tsushima current.

The coastal water of Kyushu is stated to become especially massive in the rainy season in Japan (June-July) and influences the direction and composition of the Tsushima current.

The temperature and salinities of these warm and cold waters differ considerably from each other, and they remain fairly independent, with little intermixing (Kikuchi, 1968; Inoue, 1974). However, in the areas on the southeastern to middle portion of the continental shelf, the cold waters from the Yellow Sea and the Chinese Continent and the warm water from the Tsushima current are mixed to some extent. In such areas, the salinities are stated to be 33.5–34.0‰ (Inoue, 1974).

Materials and Methods

The data on species and localities are mostly based on the results of my examination of the preserved specimens and my field surveys during the years of 1974–76 and 78, however, those on 17 species and from 19 localities are taken from Döderlein (1885), Ohshima (1934), Hayasaka (1948), Tokioka (1955), and Matsubayashi (1973). The methods of the faunal analysis are based on my thesis for the doctor's degree and Shigei (1970a, 1970b, 1971, 1973a, 1973b, 1973c, 1974, 1975a, 1975b, 1975c, 1977a, 1977b).

The sources of the preserved specimens examined in the present study are as follows:

The Misaki Marine Biological Station Collection Series I (from the intertidal & upper sublittoral zone).

Series A: Collector; Michio Shigei. Localities; Kyushu (Fukuoka, Nagasaki, Amakusa, and Kagoshima), Ohsumi Group (Tane and Yaku Isls.), Amami Group (Amami-Ohshima and Okinoerabu Isls.), Okinawa Isl., Miyako Isl., Yaeyama Group (Ishigaki, Taketomi, Kuroshima, Haderuma, and Yonaguni Isls.), and Taiwan (Chi-lung). Number of specimens; 138. Number of species; 27. Years of collecting; 1974–76, 1978, 1980.

Series B: Collector; Moritaka Nishihira of the Department of Zoology, Faculty of Science, Kyoto University. Localities; Okinawa and Ishigaki Isls. Number of specimens; 22. Number of species; 16. Years of collecting; 1972, 1974–75.

Series C: Collector; Kiyoshi Yamazato of the Department of Biology, Faculty of Science, Ryukyu University. Localities; Okinawa and Ishigaki Isls. Number of specimens; 18. Number of species; 10. Years of collecting; 1960's.

Series D: Collector; Ki Won Kim of the Department of Biology, Liberal Arts and Science College, Chonnam University. Localities; Southern Korea (Nammyun Yoolrim-ri, Tolsan-myon, and Cheju Isl.). Number of specimens; 40. Number of species; 8. Years of collecting; 1975, 1978, 1979.

Series E: Collector; Ten Shau Tan of the Department of Zoology, National Taiwan University. Locality; Taiwan (Chi-lung). Number of specimens; 32. Number of species; 5. Years of collecting; 1975.

Series F: Kinzo Matsubayashi of the Biological Society of Nagasaki Prefecture. Locality; Nagasaki (Nomo). Number of specimens; 4. Number of species; 4. Years of collecting; 1966, 1974.

Series G-K: Collectors; Taiji Kikuchi of the Amakusa Marine Biological Station (G), Takao Yamaguchi of the Aitsu Marine Biological Station (H), Hiroshi Mukai and Suguru Ohta of the Ocean Research Institute of Tokyo University (I), Hideo Nakamura of the Sesoko Marine Biological Station (J), and Shonan Amemiya of the Misaki Marine Biological Station (K). Localities; Amakusa, Ishigaki Isl., and Okinawa (Sesoko) Isl. Number of specimens; 23. Number of species; 9. Years of collecting; 1964, 1975–76, 1978, 1980.

The Misaki Marine Biological Station Collection Series II (mainly from the lower sublittoral to bathyal zones).

Series L: Collectors; Shuzo Kishida and Tadahiro Kitajima of the Seikai Regional Fisheries Laboratory. Research vessels; Yūryo-Maru No. 8 and Ryoan-Maru No. 28. Localities and Depths; the Okinawa Trough and partly the continental shelf, 125–1,130 m. Number of stations; 28. Number of specimens; 68. Number of species; 18. Year of collecting; 1978.

Series M: Collector; Hideo Yamashita of the Seikai Regional Fisheries Research Laboratory. Research vessels; the Yōkō-Maru and the Kaiyō-Maru. Localities and Depths; northern Kyushu (shelf zone), western Kyushu (shelf zone), southern Kyushu (shelf zone and partly upper bathyal zone), submarine banks, and the continental shelf, 32–430 m. Number of stations; 27. Number of specimens; 101. Number of species; 26. Years of collecting; 1962–64, 1966–67, 1971, 1975.

Series N: Collector; Katsura Oyama of the Toba Aquarium. Research vessels; the Tokaidaigaku-Maru II and the Wakashio. Localities and Depths; northern Kyushu (shelf zone), western Kyushu (shelf- and upper bathyal zone), and partly southern Kyushu (shelf- and upper bathyal zone), 38–580 m. Number of stations 20. Number of specimens; 48. Number of species; 18. Years of collecting; 1972–73.

Series O: Collector; Takashi Okutani of the National Science Museum. Research vessel; the Sōyō-Maru. Localities and Depths; southern Kyushu, submarine banks, and partly the continental shelf, the Okinawa Trough, and the Ryukyu sea shelf, 48–1,240 m. Number of stations; 19. Number of specimens; 55. Number of species; 28. Years of collecting; 1957, 1959–60, 1964–65, 1972–73, 1976–1978.

Series P: Collector; Tohru Imaoka of the Seto Marine Biological Laboratory. Research vessels; the Kagoshima-Maru and many fishing boats. Localities and Depths; southern Kyushu (shelf zone and partly upper bathyal zone), 20–380 m. Number of stations; 8. Number of specimens; 62. Number of species; 27. Years of collecting; 1973–75.

Series Q: Collector; Yoshiaki Tominaga of the University Museum, Tokyo University. Research vessels; fishing boats. Localities and Depths; uncertain (shelf zone of the East China Sea). Number of stations; 5. Number of specimens; 13. Number of species; 4. Year of collecting; 1974.

Collection Series in the laboratory other than the M.M.B.S.

Series R: Laboratory; the Department of Zoology, Faculty of Agriculture, Kyushu University. Collectors; Hayato Ikeda, Hiroshi Ohshima, and many others.

Localities; Southern Korea, Kyushu (Fukuoka, Nagasaki, and Amakusa), Fukue-, Amami-Oshima-, Okinawa-, Ishigaki-, Haderuma Isl., and Taiwan; intertidal zone and partly shelf zone. Number of specimens; about 300. Number of species; 50. Years of collecting; 1929, 1932–35, 1937, 1953, 1956, 1958.

°Series S: Laboratory; the Seikai Regional Fisheries Research Laboratory. Collector; Hideo Yamashita. Localities; northern Kyushu (shelf zone), western Kyushu (shelf zone), southern Kyushu (shelf zone, submarine banks, and partly upper bathyal zone), and the continental shelf. Number of specimens; 101. Number of species; 26. Years of collecting; 1962–64, 1966–67, 1971, 1975.

°Series T: Laboratory; the Amakusa Marine Biological Station. Collectors; Taiji Kikuchi and partly Hiroshi Ohshima. Localities; Amakusa, intertidal & upper sublittoral zone and partly lower sublittoral zone. Number of specimens; about 120. Number of species; 24. Years of collecting; 1928, 1931–32, 1940, 1962–69, 1975–76.

Series U: Laboratory; the Department of Zoology, University Museum, Tokyo University. Collectors; Shigeyasu Tokunaga and many others. Localities; Kyushu (Fukuoka, Nagasaki, and Kagoshima), Amami-Ohshima- and Okinawa Isl., intertidal-subtidal zone. Number of specimens; about 100. Number of species; 15. Years of collecting; 1896–1903.

Series V: Laboratory; the Department of Marine Ecology, Ocean Research Institute, Tokyo University. Collectors: Masuoki Horikoshi and Suguru Ohta. Research Vessel: Hakuho-Maru. Localities: the continental shelf (2 loc.), the Okinawa Trough (1 loc.), and the Ryukyu sea shelf (3 loc.). Number of specimens: 84. Number of species: 12. Years of collecting: 1968 (KH-68-2), 1973 (KH-73-2), 1974 (KH-74-3).

°Series W: Laboratory; the Department of Biology, Faculty of Science, Ryukyu University. Collector; Kiyoshi Yamazato. Localities; Okinawa- and Ishigaki Isl., intertidal-subtidal zone. Number of specimens; 35. Number of species; 10. Years of collecting; 1960's.

Series X: Laboratory; the Amami Laboratory of Medical Zoology, Institute of Medical Science, Tokyo University. Collector; Yoshihiro Hayashi. Localities; Amami-Ohshima Isl., intertidal zone. Number of specimens; 20. Number of species; 9. Year of collecting; 1977.

Series Y: Laboratory; the Imperial Household. Collectors; uncertain. Localities; Amami-Ohshima- and Okinawa Isl. Number of specimens; 11. Number of species; 8. Years of collecting; 1927, 1935.

°Series Z: Laboratory; the Department of Zoology, National Taiwan University. Collectors; Ten Shau Tan and others. Locality; Taiwan (Chi-lung). Number of specimens; about 100. Number of species; 5. Year of collecting; 1975.

The series marked by a small circle include some specimens which have been donated to the M.M.B.S. collection series.

Systematics

Systematic studies were made first and the results are used as the basic data for faunal studies.

Through the examination of the specimens, 112 species were found. From the literature, additional 17 species (asterisked in the following list) were added in the fauna. A total of 129 species of 89 genera, 35 families and 9 orders are classified as follows:

Order CIDAROIDA Claus
Family Cidaridae Gray
Subfamily Histocidarinae Mortensen
Genus *Histocidaris* Mortensen, 1903
1. *H. carinata* Mortensen, 1928
Subfamily Goniocidarinae Mortensen
Genus *Goniocidaris* L. Agassiz and Desor, 1846
Subgenus *Petalocidaris* Mortensen, 1903
2. *G. (P.) biserialis* (Döderlein, 1885)
Subgenus *Discocidaris* Döderlein, 1885
3. *G. (D.) midako* (Döderlein, 1885)
Subgenus *Aspidocidaris* Mortensen, 1928
4. *G. (A.) clypeata* Döderlein, 1885
5. *G. (A.) alba* Mortensen, 1928
Subgenus *Cyrtocidaris* Mortensen, 1927
6. *G. (C.)* sp. nov.
Genus *Rhopalocidaris* Mortensen, 1927
7. *R. rosea* Mortensen, 1928
Subfamily Stereocidarinae Lambert
Genus *Stereocidaris* Pomel, 1883
Subgenus *Stereocidaris* Pomel, 1883
8. *S. (S.) grandis* (Döderlein, 1885)
9. *S. (S.) indica philippinensis* Mortensen, 1928
10. **S. (S.) sceptriferoides* Döderlein, 1887
Subgenus *Phalacrocidaris* Lambert, 1902
11. *S. (P.) japonica* (Döderlein, 1885)
Genus *Compsocidaris* Ikeda, 1939
12. *C. pyrsacantha* Ikeda, 1939
Subfamily Stylocidarinae Mortensen
Genus *Acanthocidaris* Mortensen, 1903
13. *A. maculicolis* (Meijere, 1903)
Genus *Stylocidaris* Mortensen, 1909
14. *S. reini* (Döderlein, 1887)
15. *S. annulosa* Mortensen, 1927
16. *S. maculosa* Mortensen, 1928

17. *S. ryukyuensis* Shigei, 1975
    Genus *Chorocidaris* Ikeda, 1941
18. *C. fussispina* (Mortensen, 1928)
    Genus *Eucidaris* Pomel, 1883
19. *E. metularia* (Lamarck, 1816)
    Genus *Plococidaris* Mortensen, 1909
20. *P. verticillata* (Lamarck, 1816)
    Genus *Prionocidaris* A. Agassiz, 1863
21. *P. baculosa annulifera* (Lamarck, 1816)
22. *P. australis* (Ramsay, 1885)
    Subfamily Rhabdocidarinae Mortensen
    Genus *Phyllacanthus* Brandt, 1835
23. *P. imperialis* (Lamarck, 1816)
    Order LEPIDOCENTROIDA Mortensen
    Family Echinothuridae Thomson
    Subfamily Phormosominae Mortensen
    Genus *Phormosoma* Thomson, 1872
24. *P. bursarium* A. Agassiz, 1881
    Subfamily Kamptosominae Mortensen
    Genus *Kamptosoma* Mortensen, 1903
25. *K. asterias* (A. Agassiz, 1881)
    Subfamly Echinothuriinae Thomson
    Genus *Sperosoma* Koehler, 1897
26. *S. giganteum* A. Agassiz and H.L. Clark, 1907
    Genus *Hygrosoma* Mortensen, 1903
27. *H. hoplacantha* (Thomson, 1877)
    Genus *Calveriosoma* Mortensen, 1934
28. *C. gracile* (A. Agassiz, 1881)
    Genus *Araeosoma* Mortensen, 1903
29. *A. owstoni* Mortensen, 1904
    Genus *Hapalosoma* Mortensen, 1903
30. *H. gemmiferum* Mortensen, 1934
    Genus *Asthenosoma* Grube, 1867
31. *A. ijimai* Yoshiwara, 1887
    Order DIADEMATOIDA Duncan
    Suborder ASPIDODIADEMINA Mortensen
    Famliy Aspidodiadematidae Duncan
    Genus *Aspidodiadema* A. Agassiz, 1879
32. *A. tonsum* A. Agassiz, 1879
33. *A. intermedium* Shigei, 1977
    Suborder DIADEMINA Duncan
    Family Diadematidae Gray
    Genus *Astropyga* Gray, 1825

34. *A. radiata* (Leske, 1778)
Genus *Eremopyga* A. Agassiz and H.L. Clark, 1908
35. *E. denudata* (Meijere, 1902)
Genus *Chaetodiadema* Mortensen, 1903
36. *C. japonicum* Mortensen, 1904
Genus *Diadema* Humphrey, 1797
37. *D. setosum* (Leske, 1778)
38. *D. savignyi* (Audouin, 1828)
Genus *Echinothrix* Peters, 1853
39. *E. calamaris* (Pallas, 1774)
40. *E. diadema* (Linnaeus, 1758)
Suborder PEDININA Mortensen
Family Pedinidae Pomel
Genus *Caenopedina* A. Agassiz, 1869
41. *C. mirabilis* (Döderlein, 1885)
42. *C. indica* (Meijere, 1903)
Order ARBACIOIDA Gregory
Suborder SALENINA Mortensen
Family Saleniidae L. Agassiz
Genus *Salenia* Gray, 1835
43. *S. cincta* A. Agassiz and H.L. Clark, 1907
Suborder ARBACINA Gregory
Family Arbaciidae Gray
Genus *Coelopleurus* L. Agassiz, 1840
44. *C. maculatus* A. Agassiz and H.L. Clark, 1907
45. *C. undulatus* Mortensen, 1934
Suborder PHYMOSOMATINA Mortensen
Family Stomopneustidae Mortensen
Genus *Stomopneustes* L. Agassiz, 1841
46. *S. variolaris* (Lamarck, 1816)
Order ECHINOIDA Claus
Suborder TEMNOPLEURINA Mortensen
Family Temnopleuridae A. Agassiz
Subfamily Temnopleurinae A. Agassiz
Genus *Temnopleurus* L. Agassiz, 1841
Subgenus *Temnopleurus* L. Agassiz, 1841
47. *T. (T.) toreumaticus* (Leske, 1778)
48. *T. (T.) hardwickii* (Gray, 1855)
Subgenus *Toreumatica* Gray, 1855
49. *T. (T.) reevesii* (Gray, 1855)
50. *T. (T.) apodus* (A. Agassiz and H.L. Clark, 1907)
Genus *Salmaciella* Mortensen, 1942
51. *S. dussumieri* (L. Agassiz, 1846)
Genus *Microcyphus* L. Agassiz, 1841

52. *M. olivaceus* (Döderlein, 1885)
Genus *Mespilia* Desor, 1846
53. *M. globulus* (Linnaeus, 1758)
54. *M. levituberculatus* Yoshiwara, 1898
Genus *Temnotrema* A. Agassiz, 1863
55. *T. sculptum* A. Agassiz, 1863
Subfamily Trigonocidarinae Mortensen
Genus *Opechinus* Desor, 1856
56. **O. variabilis* (Döderlein, 1885)
Genus *Prionechinus* A. Agassiz, 1879
57. **P. forbesianus* (A. Agassiz, 1881)
Genus *Lamprechinus* Döderlein, 1905
58. **L. sculptus* Mortensen, 1942
Family Toxopneustidae Troschel
Genus *Nudechinus* H.L. Clark, 1912
59. *N. multicolor* (Yoshiwara, 1898)
Genus *Toxopneustes* L. Agassiz, 1841
60. *T. pileolus* (Lamarck, 1816)
61. *T. elegans* Döderlein, 1885
Genus *Tripneustes* L. Agassiz, 1841
62. *T. gratilla* (Linnaeus, 1758)
Genus *Pseudoboletia* Troschel, 1869
63. *P. maculata* Troschel, 1869
Suborder ECHININA Claus
Family Echinidae Gray
Genus *Echinus* Linnaeus, 1758
64. *E. lucidus* Döderlein, 1885
Family Strongylocentrotidae Gregory
Genus *Strongylocentrotus* Brandt, 1835
65. *S. nudus* (A. Agassiz, 1863)
Genus *Hemicentrotus* Mortensen, 1942
66. *H. pulcherrimus* (A. Agassiz, 1863)
Genus *Pseudocentrotus* Mortensen, 1903
67. *P. depressus* (A. Agassiz, 1863)
Family Echinometridae Gray
Genus *Echinostrephus* A. Agassiz, 1863
68. *E. aciculatus* A. Agassiz, 1863
69. *E. molaris* (Blainville, 1825)
Genus *Anthocidaris* Lütken, 1864
70. *A. crassispina* (A. Agassiz, 1863)
Genus *Echinometra* Gray
71. *E. mathaei* (Blainville, 1825)
Genus *Heterocentrotus* Brandt, 1835

72. *H. mammillatus* (Linnaeus, 1758)
    Genus *Colobocentrotus* Brandt, 1835
73. *C. mertensii* Brandt, 1835
    Family Parasaleniidae Mortensen
    Genus *Parasalenia* A. Agassiz, 1863
74. *P. gratiosa* A. Agassiz, 1863
    Order HOLECTYPOIDA Duncan
    Suborder ECHINONEINA Hawkins
    Family Echinoneidae Wright
    Genus *Echinoneus* Leske, 1778
75. *E. cyclostomus* Leske, 1778
    Genus *Micropetalon* A. Agassiz and H.L. Clark, 1907
76. *M.* sp. nov.
    Order CASSIDULOIDA Claus
    Suborder NEOLAMPADINA Philip
    Family Neolampadidae Lambert
    Genus nov.
77. Genus and sp. nov.
    Suborder CASSIDULINA Claus
    Family Pliolampadidae Kier
    Genus *Oligopodia* Duncan, 1889
78. *O. epigona* (Martens, 1865)
    Family Echinolampadidae Gray 1825
    Genus *Echinolampas* Gray, 1825
79. *E. koreana* H.L. Clark, 1925
80. *E. sternopetala* A. Agassiz and H.L. Clark, 1907
    Order CLYPEASTEROIDA A. Agassiz
    Suborder CLYPEASTERINA A. Agassiz
    Family Clypeasteridae L. Agassiz
    Genus *Clypeaster* Lamarck, 1801
81. *C. virescens* Döderlein, 1885
82. *C. japonicus* Döderlein, 1885
83. *C. ohshimensis* Ikeda, 1936
84. *C. fervens* Koehler, 1922
85. **C. reticulatus* (Linnaeus, 1758)
    Family Arachnoididae Duncan
    Genus *Arachnoides* Leske, 1778
86. **A. placenta* (Linnaeus)
    Souborder LAGANINA Mortensen
    Family Fibulariidae Gray
    Genus *Fibularia* Lamarck, 1816
87. *F. ovulum* Lamarck, 1816

88. *F.* sp. nov.

Genus *Fibulariella* Mortensen, 1948

89. *F. acuta* (Yoshiwara, 1898)

Genus *Echinocyamus* Van Phelsum, 1774

90. **E. crispus* Mazzetti, 1893
91. *E. subconicus* Mortensen, 1948

Family Laganidae Desor

Genus *Laganum* Link, 1807

92. *L. fudsiyama* Döderlein, 1885

Genus *Peronella* Gray, 1855

93. *P. lesueuri* (Valenciennes, 1841)
94. *P. japonica* Mortensen, 1948
95. *P. rubra* Döderlein, 1885
96. *P. pellucida* Döderlein, 1885

Family Scutellidae Gray

Genus *Scaphechinus* A. Agassiz, 1863

97. *S. mirabilis* A. Agassiz, 1863

Family Astriclypeidae Stefanini

Genus *Echinodiscus* Leske, 1778

98. **E. auritus* Leske, 1778
99. *E. tenuissimus* (L. Agassiz, 1847)

Genus *Astriclypeus* Verrill, 1867

100. *A. manni* Verrill, 1867

Order SPATANGOIDA Claus

Suborder URECHININA Hawkins

Family Holasteridae Pictet

Genus *Stereopneustes* Meijere, 1903

101. *S. relictus* Meijere, 1903

Family Pourtalesiidae A. Agassiz

Genus *Pourtalesia* A. Agassiz, 1869

102. **P. laguncula* A. Agassiz, 1879

Suborder SPATANGINA Claus

Family Hemiasteridae H.L. Clark

Genus *Hemiaster* Desor, 1847

103. **H. expergitus gibbosus* A. Agassiz, 1881

Family Palaeostomatidae Lovén

Genus *Palaeostoma* Lovén, 1872

104. **P. mirabile* (Gray, 1851)

Family Pericosmidae Lambert

Genus *Pericosmus* L. Agassiz, 1847

105. *P. cordatus* Mortensen, 1950

Family Schizastridae Lambert

Genus *Faorina* Gray 1851

106. *F. chinensis* Gray, 1851
Genus *Schizaster* L. Agassiz, 1836
107. *S. lacunosus* (Linnaeus, 1758)
108. *S.* sp. nov.
Genus *Moira* A. Agassiz, 1872
109. *M. lachesinella* Mortensen, 1930
Family Aeropsidae Lambert
Genus *Aceste* Thomson, 1877
110. **A. ovata* A. Agassiz and H.L. Clark, 1907
Family Brissidae Gray
Genus *Brissopsis* L. Agassiz, 1840
111. **B. luzonica* (Gray, 1851)
Genus *Gymnopatagus* Döderlein, 1901
112. *G. magnus* A. Agassiz and H.L. Clark, 1907
Genus *Brissus* Gray, 1825
113. *B. latecarinatus* (Leske, 1778)
114. *B. agassizii* Döderlein, 1885
Genus *Metalia* Gray, 1855
115. *M. spatagus* (Linnaeus, 1758)
116. *M. dicrana* H.L. Clark, 1917
Family Spatangidae Gray
Subfamily Spatanginae Gray
Genus *Saptangus* Müller, 1776
117. *S. paucituberculatus* A. Agassiz and H.L. Clark, 1907
Subfamily Maretiinae Lambert
Genus *Pseudomaretia* Koehler, 1914
118. *P. alta* (A. Agassiz, 1863)
119. *P. tylota* (H.L. Glark, 1917)
Genus *Maretia* Gray, 1855
120. **M. planulata* (Lamarck, 1816)
Family Loveniidae Lambert
Subfamily Loveniinae Lambert
Genus *Lovenia* Desor, 1847
121. *L. elongata* (Gray, 1845)
122. *L. gregalis* Alcock, 1893
123. *L. triforis* Koehler, 1914
Genus *Homolampas* A. Agassiz, 1874
124. *H. lovenioides* Mortensen, 1948
Subfamily Echinocardiinae Cooke
Genus *Echinocardium* Gray, 1825
125. *E. cordatum* (Pennant, 1777)
Family Asterostomatidae Pictet
Genus *Linopneustes* A. Agassiz, 1881

126. *L. fragilis* (Meijere, 1904)
127. **L. murrayi* (A. Agassiz, 1879)

Genus *Argopatagus* Agassiz, 1879

128. **A. vitreus* A. Agassiz, 1879
129. **A. planus* (A. Agassiz and H.L. Clark, 1907)

The species and subspecies placed as synonyms in the present study are as follows (the valid names are shown by the species number in the above list):

Goniocidaris crassa Mortensen—syn. of No. 5

Stereocidaris grandis hyatorina Mortensen and *Stereocidaris microtuberculata* (Yoshiwara)—syns. of No. 8

Stylocidaris fussispina Mortensen—syn. of No. 18

Prionocidaris glandulosa (Meijere)—syn. of No. 22

Asthenosoma tessellatum A. Agassiz reported by A. Agassiz and H.L. Clark (1907b) [non. *Araeosoma tessellatum* (A. Agassiz)] and *Asthenosoma pyrochloa* (A. Agassiz and H.L. Clark)—syns. of No. 28

Asthenosoma owstoni A. Agassiz and H.L. Clark and *Asthenosoma bicolor* A. Agassiz and H.L. Clark—syns. of of No. 29

Asthenosoma pellucidum A. Agassiz reported by A. Agassiz and H.L. Clark (1907b) (non. *A. pellucidum* A. Agassiz)—syn. of No. 30

Diadema clarki Ikeda—syn. of No. 37

Hemipedina mirabilis Döderlein—syn. of No. 41

Coelopleurus undulatus polymorphus Mortensen—syn. of No. 45

Temnopleurus reynaudi A. Agassiz—syn. of No. 49

Salmacopsis olivacea Döderlein—syn. of No. 52

Pleurechinus variegatus Mortensen—syn. of No. 55

Pleurechinus variabilis Döderlein—syn. of No. 56

Prionechinus ruber A. Agassiz and H.L. Clark—syn. of No. 57

Parasalenia gratiosa boninensis Mortensen—syn. of No. 74

Echinocyamus scaber subconicus Mortensen—syn. of No. 91

Laganum diploporum A. Agassiz and H.L. Clark—syn. of No. 92

Scaphechinus brevis (Ikeda)—syn. of No. 97

Schizaster japonicus A. Agassiz—syn. of No. 107

Aceste purpurea A. Agassiz and H.L. Clark—syn. of No. 110

Brissopsis oldhami Alcock reported by A. Agassiz and H.L. Clark (1907b) (non. *B. oldhami* Alcock)—syn. of No. 111

Palaeopneustes fragilis Meijere—syn. of No. 126

Linopneustes excentricus Meijere reported by A. Agassiz and H.L. Clark (1907b) (non. *L. excentricus* Meijere)—syn. of No. 127

Meijerea excentrica A. Agassiz and H.L. Clark—syn. of No. 128

Meijerea plana A. Agassiz and H.L. Clark—syn. of No. 129

The Vertical Distribution

Vertical distributions of species in the present region are shown in Fig. 3 based on the data as follows:

My examination of the Specimen Series A-Z and field surveys, Nos. 1–9, 11–55, 59–84, 87–89, 91–97, 99–101, 105–109, 112–119, 121–126; Mortensen (1928b), No. 10; A. Agassiz and H.L. Clark (1907b), Nos. 56, 57, 102, 103, 110, 111, 127–129; Mortensen (1943a), No. 58; Hayasaka (1948), Nos. 85, 86, 98; Mortensen (1948d), No. 90; Döderlein (1885), Nos. 104, 120.

It is fairly clearly seen in Fig. 3 that the vertical distribution of each species falls into three groups in general: 0–ca. 30 m; ca. 30–200 m; and ca. 200–3,500 m. These depth ranges just correspond to the well-known, vertical zones for the marine faunas (Ekman, 1953; Hedgepeth, 1957; Pérès, 1961; Horikoshi, 1962 a-b, 1971; Zenkevitch, 1963; Briggs, 1974). In the present paper, each zone is described as the intertidal & upper sublittoral, the lower sublittoral, and the bathyal zone. Among these, the upper and lower sublittoral zones can be united as the shelf zone (Ekman, 1953).

The species found in each of these zones are as follows:

Shelf zone:

1) *Intertidal & Upper sublittoral zone:* Nos. 19, 20, 21, 23, 31, 34, 37, 38, 39, 40, 46, 47, 48, 51, 53, 54, 59, 60, 61, 62, 63, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 82, 83, 85, 86, 87, 88, 89, 93, 94, 95, 97, 98, 99, 100, 107, 108, 109, 113, 114, 115, 116, 118, 120, 121, 125.

2) *Lower sublittoral zone:* Nos. 2, 3, 4, 6, 7, 11, 13, 14, 15, 16, 17, 18, 19, 21, 22, 29, 30, 35, 36, 41, 43, 44, 45, 48, 49, 50, 52, 55, 56, 76, 77, 78, 79, 80, 81, 84, 90, 91, 92, 96, 104, 105, 106, 107, 118, 121, 122, 123, 125.

Bathyal zone:

Nos. 1, 5, 8, 9, 10, 12, 14, 18, 24, 25, 26, 27, 28, 32, 33, 41, 42, 57, 58, 64, 92, 101, 102, 103, 105, 110, 111, 112, 117, 119, 124, 126, 127, 128, 129.

The following species overlap between the upper and lower sublittoral zones (their deepest occurrence is shown by depth in parenthesis):

No. 118 (−51 m); No. 125 (−77 m); No. 121 (−82 m); No. 19 (−120 m); No. 48 (−120 m); No. 21 (−130 m); No. 107 (−145 m).

For these 7 species (7.1% of the total), the boundary between the upper and the lower sublittoral zones seems to be meaningless. However, for the other 92 species (92.9% of the total), this boundary is meaningful.

The following species overlap between the lower sublittoral and the bathyal zones (their deepest occurrence is shown by depth in parenthesis):

No. 41 (−230 m); No. 92 (−280 m); No. 105 (−208 m); No. 14 (−310 m); No. 18 (−400 m).

These species are rare in the bathyal zone, where they occur only in the upper

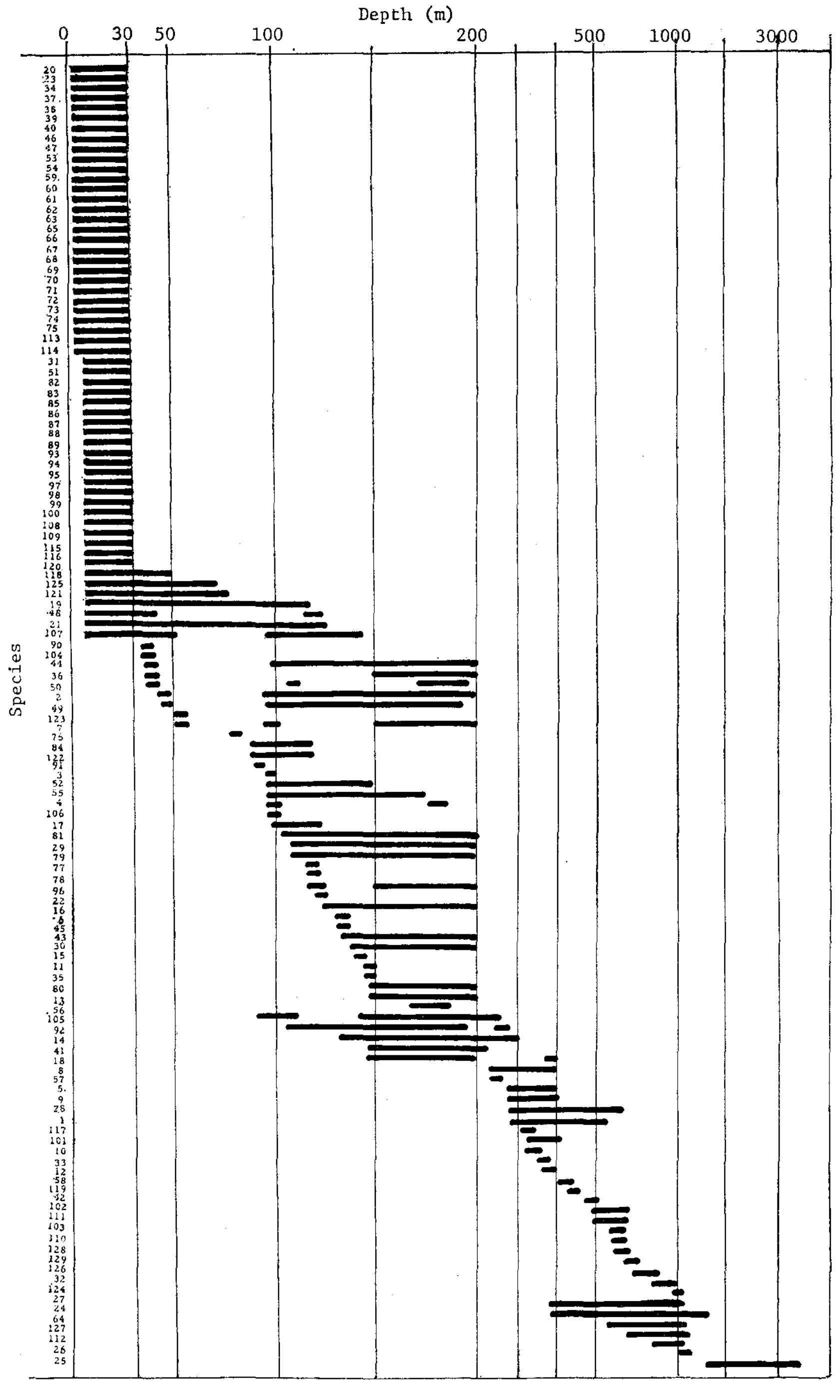

Figure 3. Vertical distributions of species in the present region. Species are shown by the species numbers given in the systematic list.

part of the upper bathyal zone. Therefore, they may be best considered as shelf elements. If these species are excluded from the bathyal elements, the bathyal fauna can be said to be perfectly independent from the others. Even if these species are included, the shelf and bathyal zones are clearly demarcated by the distribution of the other 124 species.

Studies on the Faunal Elements

1) *Shelf species*

Distributions of the shelf species in Japan and the Indo-West Pacific seas are shown in Fig. 4 based on the following data:

For Japan and its adjacent seas (areas A-L), the data are based on the results of my examination of specimens from various sources (Shigei, unpublished), except those for area A on Nos. II, III (Baranova, 1957); area F on Nos. 18 (Mortensen, 1928b), 56 (Döderlein, 1885); area G on Nos. 11, 14, 92 (Morishita, 1969), 56, 81, 92 (A. Agassiz and H.L. Clark, 1907b); area I on Nos. 2, 3, 11, 19–21, 29, 31, 34, 36, 39–41, 44, 47, 49–51, 54, 72–75, 80–82, 85, 89, 90, 94, 96, 100, 107, 114, 121, 125 (Utinomi, 1954). For the Indo-West Pacific seas (areas M-Q), the data are taken from A. Agassiz (1881), A. Agassiz and H.L. Clark (1907 a-b, 1908, 1909), H.L. Clark (1912, 1914, 1917, 1925), Döderlein (1885, 1887, 1906), Koehler (1914, 1922), Meijere (1904), Mortensen (1903, 1904 a-b, 1907, 1927, 1928 b, 1935, 1940 a-b, 1943a-b, 1948b-d, 1950b, 1951).

From Fig. 4, the following four patterns of distribution can be seen.

Pattern 1; distributional range from A (Sakhalin-Kuriles) or B (northeastern Hokkaido) to as far south as E (Kashima Nada).

Pattern 2; distributional range from C (southwestern Hokkaido) to as far south as F (Sagami Bay) (rarely to M) or K (Kyushu).

Pattern 3; distributional range from F (Sagami Bay) to K (Kyushu) (rarely to G or in F alone).

Pattern 4; broad distributional range in M-Q (Indo-West Pacific seas) extending as far north as K (Kyushu), I (Kii Peninsula), or F (Sagami Bay).

The submarine climate in each of the above distributional ranges has been well known as follows; subarctic in pattern 1, temperate (or cold-temperate) in pattern 2, subtropical (or warm-temperate) in pattern 3, and tropical (partly subtropical) in pattern 4.

Based on these facts and the data in Fig. 4, the shelf species are classified as the faunal elements as follows:

Subarctic elements; None (Nos. I-VIII).

Temperate (or cold-temperate) elements; Nos. 48, 65, 66, 97, 125.

Subtropical elements (someone may be warm-temperate elements); Nos. 2, 3, 4, 7, 11, 18, 29, 30, 36, 41, 45, 52, 54, 55, 56, 61, 67, 70, 79, 80, 82, 88, 94, 96, 105, 107, 109, 114.

Figure 4. Distributions of the shelf species in Japan and the Indo-West Pacific seas. Species are shown by the species numbers given in the systematic list.
Roman numerals indicate the following species which are added for a comparison:
I-*Strongylocentrotus polyacanthus* A. AGASSIZ and H.L. CLARK; II-*Strongylocentrotus droebachiensis* (MÜLLER); III-*Strongylocentrotus pulchellus* A. AGASSIZ and H.L. CLARK: IV-*Echinarachnius parma* (LAMARCK); V-*Strongylocentrotus sachalinicus* DÖDERLEIN: VI-*Strongylocentrotus intermedius* (A. AGASSIZ); VII-*Scaphechinus griseus* (MORTENSEN); VIII-*Glyptocidaris crenularis* A. AGASSIZ.
Distribution area:
A-Sakhalin and Kurile Islands; B-Northern and eastern Hokkaido; C-Southwestern Hokkaido; D-Sanriku; E-Kashima Nada; F-Sagami Bay; G-Suruga Bay; H-Shima; I-Kii Peninsula (southernmost part); J-Tosa Bay; K-Kyushu; L-Okinawa; M-Southeast Asia; N-Northern Australia; O-Indian Ocean; P-East Africa; Q-Hawaii.

Tropical elements; Nos. 13, 14, 15, 16, 19, 20, 21, 22, 23, 31, 34, 35, 37, 38, 39, 40, 43, 44, 46, 47, 49, 50, 51, 53, 59, 60, 62, 63, 68, 69, 71, 72, 73, 74, 75, 77, 78, 81, 84, 85, 86, 87, 89, 90, 91, 92, 93, 95, 98, 99, 100, 104, 106, 113, 115, 116, 118, 120, 121, 122, 123.

Endemic (or uncertain) elements; Nos. 6, 17, 76, 83, 108.

2) *Bathyal species*

Distributions of the bathyal species in the world seas are shown in Fig. 5 based on the following data:

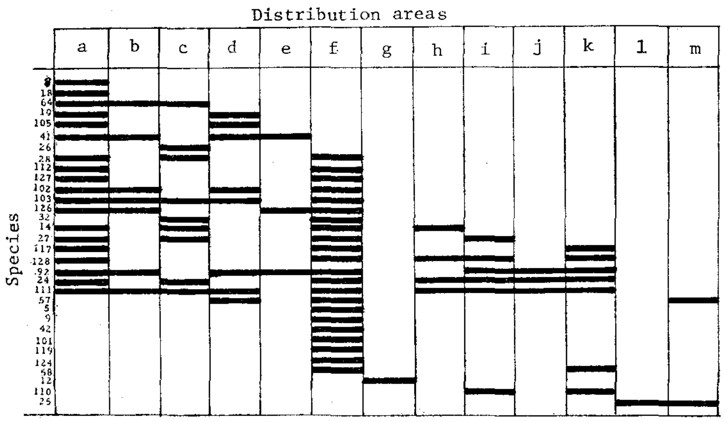

Figure 5. Distributions of the bathyal species in the world seas.
Species are shown by the species number given in the systematic list.
Distribution areas:
a-Sagami Bay; b-Suruga Bay; c-off eastern part of Central Japan; d-off Kii Peninsula; e-Tosa Bay; f-Ogasawara sea; g-Southeast Asia; h-Northern Australia; i-Indian Ocean; j-East Africa; k-Hawaii; l-Central Pacific; m-Southeastern Pacific.

For Japanese seas (areas a-f), the data are based on the results of my examination of specimens from various sources (Shigei, unpublished), except those for area a on Nos. 18 (Mortensen, 1928b), 127 (A. Agassiz, 1881), 128 (A. Agassiz and H.L. Clark, 1907b); area b on Nos. 102, 103 (A. Agassiz and H.L. Clark, 1907b); area c on Nos. 24, 26–28, 32, 64, 103, 111 (A. Agassiz and H.L. Clark, 1907b); area d on Nos. 10, 41, 57, 92, 102, 103, 111 (A. Agassiz and H.L. Clark, 1907b). For the Indo-West Pacific seas (areas g-m), the data are taken from A. Agassiz (1881), Agassiz and H.L. Clark (1907a-b, 1908, 1909), H.L. Clark (1912, 1914, 1917, 1925), Döderlein (1885, 1887, 1906), Koehler (1914, 1922), Meijere (1904), Mortensen (1903, 1904a-b, 1907, 1927, 1928b, 1935, 1940a-b, 1943a-b, 1948b-d, 1950b, 1951).

As for the bathyal elements, climatological definition can not be applied. In the present paper, the species which have been known only from the areas a-e are tentatively described as the Japanese element. From Fig. 5, each species is classified as the faunal element as follows:

Japanese elements (someone may be ubiquitous); Nos. 8, 10, 18, 26, 41, 64, 105.

Endemic (or uncertain) elements; Nos. 1, 33, 129.

Ubiquitous elements; Nos. 5, 9, 12, 14, 24, 25, 27, 28, 32, 42, 57, 58, 92, 101, 102, 103, 110, 111, 112, 117, 119, 124, 126, 127, 128.

The Intertidal & Upper Sublittoral Fauna

The localities where the specimens from the intertidal & upper sublittoral zone were collected are shown in maps (Figs. 6–7).

The result of the specimen examination is shown as a table (Tab. 1).

The data in Table 1 were rearranged for the faunal analysis, and are shown as a figure of geographical distributions of the intertidal & upper sublittoral species (Fig. 8).

Based on Figure 8, there can be drawn three lines which show sharp boundary to the distribution patterns of several species. The locations of such lines and the zoogeographical significance of the lines may be as follows:

Line 1 is drawn between area A (the Korea Peninsula) and areas B (Cheju Island)-C (the Tsushima Group):

The northernmost localities of such subtropical species as Nos. 67 (*Pseudocentrotus depressus*), 70 (*Anthocidaris crassispina*), 88 (*Fibularia* n. sp.), 89 (*Fibulariella acuta*), 54 (*Mespilia levituberculatus*), 114 (*Brissus agassizii*) and 82 (*Clypeaster japonicus*), and such tropical species as Nos. 31 (*Asthenosoma ijimai*), 60 (*Toxopneustes pileolus*), 118 (*Pseudomaretia alta*) and 37 (*Diadema setosum*) are in areas B or C (Fig. 8).

Such temperate species as Nos. 48 (*Temnopleurus hardwickii*) and 65 (*Strongylocentrotus nudus*) become very rare in the south of this line: the former reappears in the lower sublittoral zone of the eastern portion of the continental shelf (see next chapter) and the latter occurs, though rarely, in the Tsushima Group.

Line 2 is drawn between area I (the Ohsumi Group) and area J (the Tokara Group):

The southernmost localities of such temperate species as Nos. 66 (*Hemicentrotus pulcherrimus*) and 125 (*Eichinocardium cordatum*), and such subtropical species as Nos. 67 (*Pseudocentrotus depressus*), 70 (*Anthocidaris crassispina*) and 82 (*Clypeaster japonicus*) are in area I.[1] The genus of *Echinostrephus* found in the north of this line is No. 68 (*E. aciculatus*), while that found in the south (except Taiwan) is No. 69 (*E. molaris*) (Fig. 8).

The southernmost localities of such temperate species as No. 97 (*Scaphechinus mirabilis*), and such subtropical species as Nos. 107 (*Schizaster lacunosus*), 54 (*Mespilia levituberculatus*), 114 (*Brissus agassizii*), and 61 (*Toxopneustes elegans*) may be in area H

1) I made field surveys at the shore of Yaku and Tane Islands in 1978: Nos. 66, 125, and 67 were very rare; No. 70 was rather common; and No. 68 was common. None of these species were found at the Amami, the Okinawa and the Yaeyama Groups during my surveys in 1974–76, and 1978.

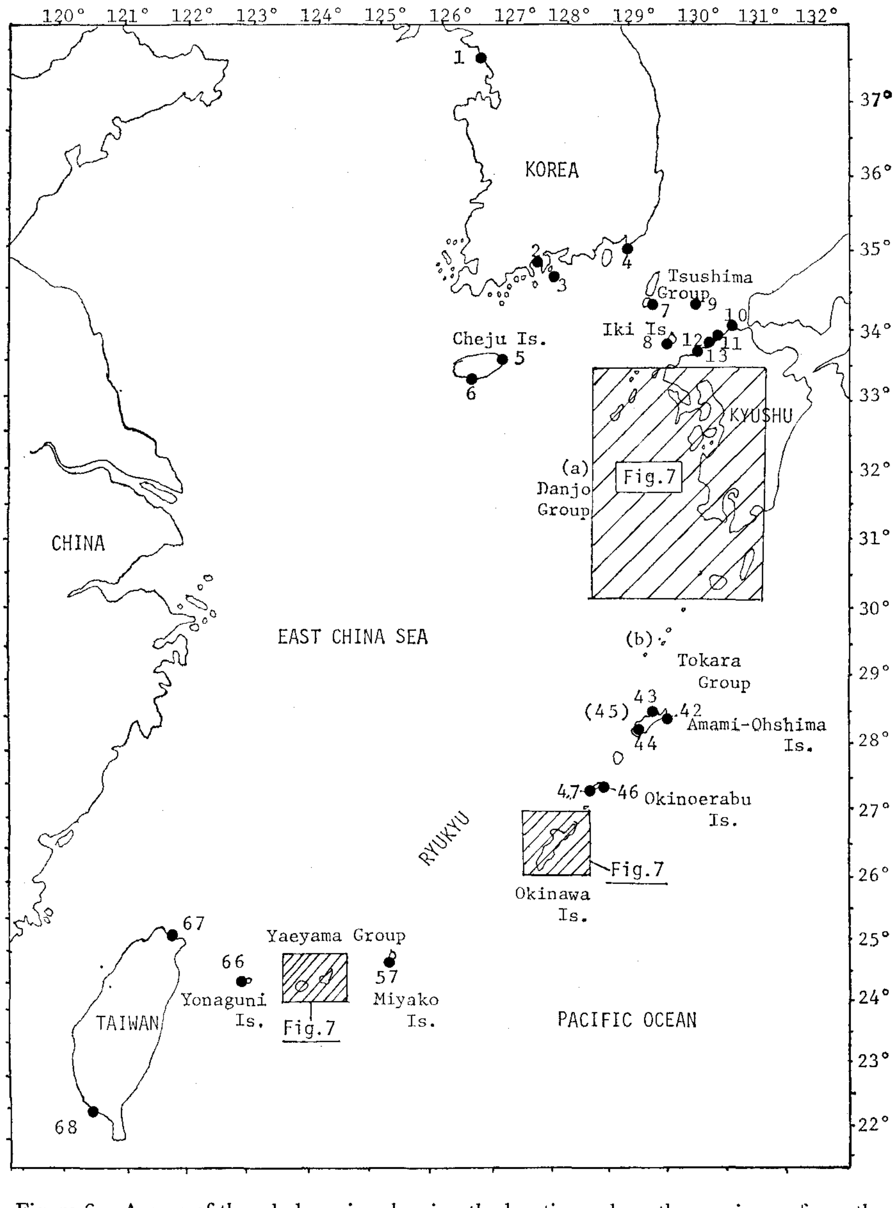

Figure 6. A map of the whole region showing the locations where the specimens from the intertidal & upper sublittoral zone were collected.

1-Inchon; 2-Nam-myun Yoolrim-ri; 3-Tolsan-myon; 4-Pusan; 5-Sungsanpo; 6-Sukipo; 7-Izuhara; 8-Gonoura; 9-Okinoshima 10-Iwaya; 11-Tsuyazaki; 12-Hakata Bay; 13-Keya; 42-Yoh (Kasari); 43-Naze; 44-Koniya; 45-uncertain (Amami-Ohshima); 6-Wadomari; 47-Tina; 57-Kuruma; 66-Hikawa; 67-Chi-lung; 68-Kao-hsiung; a-Mejima; b-Nakanoshima and Takarajima.

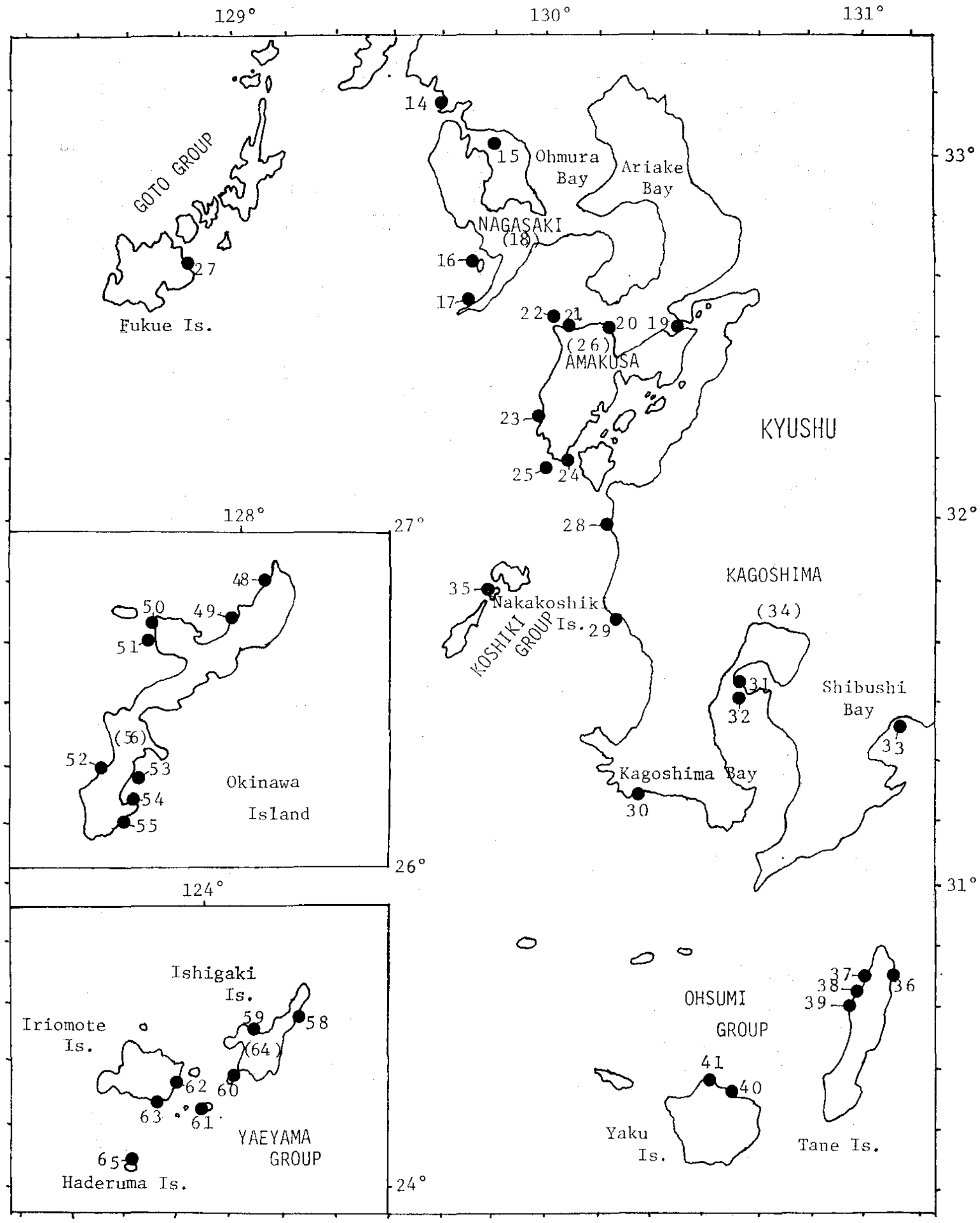

Figure 7. Enlarged maps of the areas in Fig. 6 showing the locations where the specimens from the intertidal & upper sublittoral zone were collected.

14-Sasebo; 15-Omura Bay; 16-Iojima; 17-Nomo; 18-uncertain (Nagasaki); 19-Matsushima; 20-Oniike; 21-Tomioka; 22-off Tomioka; 23-Sakitsu; 24-Ushibuka; 25-off Ushibuka; 26-uncertain (Amakusa); 27-Fukue; 28-Akune; 29-Kushikino; 30-Makurazaki; 31-Sakurajima; 32-off Sakurajima; 33-Shibushi Bay; 34-uncertain (Kagoshima); 35-Taira; 36-Iseki; 37-Nishinoomote; 38-Yokino; 39-Sumiyoshi; 40-Miyanoura; 41-Shitogo; 48-Uka; 49-Kijoka; 50-Toguchi; 51-Sesoko; 52-Minatogawa; 53-Nakagushuku Bay; 54-Itanma; 55-Tamagusuku; 56-uncertain (Okinawa); 58-Ibaruma; 59-Kabira Bay; 60-Taketomi; 61-Kuroshima; 62-Komi; 63-Haemi; 64-uncertain (Yaeyama).

Table 1. Species occurrences at the localities in the intertidal & upper sublittoral region. Species are shown by the species number given in the systematic list. Localities are shown by the station numbers and a-b in Figs. 6–7. Sources of the data are shown in parentheses by capital letters which have been marked at the head of each specimen series in "Materials and methods". The data on the localities without parenthesis are based on my field surveys. Roman numerals indicate the data introduced from the following papers and informations: *I-Ohshima (1934); *II-Matsubayashi (1973); *III-Döderlein (1885); *IV-Yoshiwara (1901); *V-Tokioka (1953) in which species No. 87 was reported as *Fibularia acuta*; *VI-Hayasaka (1948) in which species Nos. 19 and 70 were reported each as *Prionocidaris baculosa* and *Strongylocentrotus tuberculatus*; *VII-oral informations.

Species	Localities (Sources of the data)
19	b(*V), 52(C), 56(W), 59(A,J), 66(*VI)
20	17(F), b(*V), 44(X), 45(Y), 51(A,J,K), 52(B), 56(C,R), 59(A), 65(R)
21	17(F), 22(T), 27(R), 33(P), 41(*VII), 56(*VII)
23	51(B,K)
31	9(*I), 22(T), 25(T), 31(A), 32(P)
34	21(T), 26(T), 56(*VII)
37	9(*I), 21, 24, 26(R,T), a(*II), 28(U), 31(A), 34(Y), 36, 38–40, 41(A), 42, 44, 46, 47, 51(A,B), 56(C), 57, 58, 59(A,R), 60–62, 65, 66, 67(R,Z), 68(*VII)
38	21(R,T), 26(R), 31, 36, 38, 39, 41(A), 42, 44(Y), 51(A), 56(C), 57, 58, 59(A,R), 60–62, 65, 67(R)
39	36(A), b(*V), 42, 51(A,J), 59(A,R), 64(R), 65(R), 68(R)
40	56(C), 59(A,R)
46	30(U), 36, 37, 38(A), 39, 40(A), 41(A), 42, 43(R), 44(A,X), 46(A), 47(A), 51(A), 56(B,R), 57, 58, 59(A,R), 60–63, 65, 66, 67(A,E,R), 68(*VI)
47	2(D), 3(D), 4(R), 12(A,R), 21(T), 27(R), 34(U)
48	1(D), 2(D)
51	19(H), 21(G,T), 22(T), 23(T), 26(T)
53	51(A,B), 64(R)
54	8(U), 9(*I), 12(R), 21(T), 26(R), 28(R)
59	59(B)
60	7(R), 12(R), 21(T), 26(R), 28(U), 39(A), 44(Y), 45(R), 51(A), 53(B), 56(R), 57, 59(A), 64(R)
61	17(F), 29(U), 31(A), 32(Y)
62	16(F), 21(T), 24(T), 26(R), 31, 39(A), 41(A), b(*V), 42(A), 44(A,U), 47(A), 51(A), 52(U), 53(B), 57(A), 59(A,R), 62(A), 65(A,R), 66(A), 67(R), 68(R)
63	26(R), 43(R), 51(A), 56(B), 59(R)
65	2(D), 3(D), 7(*VII)
66	2(D), 3(D), 4(R), 7(R), 8(R), 9(*I), 12(R), 13(R), 14(U), 21(A.T), 26(R), a(*II), 29(U), 31(A), 36(A), 38(A)
67	5(D), 7(R), 8(R), 9(R), 12(R), 21(A,T), 26(R), 31(A), 41(*VII), 67(R)
68	21(T), 24(R), 31(*VII), 37(A), 38(A), 39(A), 41(A), 67(E), 68(R)
69	42(A), 46(A), 51(A), 53(B), 59(A)
70	5(R), 6(D), 7(R), 9(*I), 11(R), 12(R), 14(U), 21(A,T), 26(R), 27(R), a(*II), 29(U), 31(A), 33(P), 36(A), 37, 38(A), 39, 40, 41(A), 67(E,R), 68(*VI)
71	21(T), 24(T), 26(R), a(*II), 29(U), 30(U), 31, 33(U) 36, 37, 38(A), 39, 40(A), b(*V), 42(A), 44(A), 46(A), 47(A), 51(A), 53(B), 56(R,U), 57, 58(A), 59(A,R), 60, 61, 62(A), 63, 64(R), 65(A,R), 66(A), 67(E,R), 68(R)
72	41(A), 42, 44(U,X), 45(Y), 46, 47, 51(A), 56(R,U), 57, 59(A,R), 64(R), 65(R), 68(R)
73	36(A), b(*V), 45(U), 48(C), 67(*VI), 68(R)

Table 1. (continued)

Species	Localities (Sources of the data)
74	26(R), 28(R), 51(A), 59(A), 64(R)
75	21(T), 24(R), 41(A), b(*V), 56(*VIII), 59(R), 67(*IV), 68(*VI)
82	7(R), 21(T), 24(R), 27(R), a(*II), 28(R), 34(U), 35(N), 37(A), 39(A)
83	45(R)
85	68(*VI)
86	68(*VI)
87	b(*V), 59(I)
88	8(N), 21(T)
89	8(N), 11(T), 21(T), 27(R)
93	43(R), 50(B), 56(C), 63(A), 64(R), 67 (*VI), 68(*VI)
94	12(R), 19(H), 20(T), 26(R)
95	12(R)
97	2(D), 3(D), 12(R), 23(T), 27(R), 33(R)
98	68(*VI)
99	39(*IV), 45(*IV), 50(R), 56(C)
100	11(R), 12(R), 15(R), 26(R), 44(Y)
107	2(D), 3(D), 21(R), 28(R), 32(S), 33(P)
108	59(A,R)
109	12(R), 21(T)
113	52(B), 56(C), 59(B), 64(R)
114	7(R), 10(R), 21(T), 26(R), 28(R)
115	64(R)
116	55(B), 56(C), 64(R)
118	7(*VIII), 11(R), 22(*VII), 67(*VI)
120	34(*III)
121	12(R), 22(T), 27(R)
125	11(R), 21(T), 33(P), 40(A)

(Kagoshima) (Fig. 8), however, there remains the possibility of their occurrences in area I.

For the distribution of the tropical species, this line may be not very important. The tropical species tend to become gradually rare toward the north. The northern boundary of the distribution range of such species as Nos. 19, 87, 69 and 93 may be around this line or at the north of area K (the Amami Group), and that of such species as Nos. 23, 40, 53, 113 and 116 may be at the north of area L (the Okinawa

Figure 8. Geographical distributions of the intertidal & upper sublittoral species. Species are shown by the species numbers given in the systematic list.
Distribution area:
A-Korea Peninsula (southern part) (Sts. 1–4); B-Cheju Island (Sts. 5–6); C-Tsushima-Iki Group (Sts. 7–9); D-Northern Kyushu (Sts. 10–13); E-Western-Southwestern Kyushu (Sts. 14–26); F-Goto Group (St. 27); G-Danjo Group (St. a); H-Southern Kyushu (Sts. 28–35); I-Ohsumi Group (Sts. 36–41); J-Tokara Group (St. b); K-Amami Group (Sts. 42–47); L-Okinawa Group (Sts. 48–56); M-Miyako Group (St. 57); N-Yaeyama Group (Sts. 58–66); O-Northern Taiwan (St. 67); P-Southern Taiwan (St. 68).

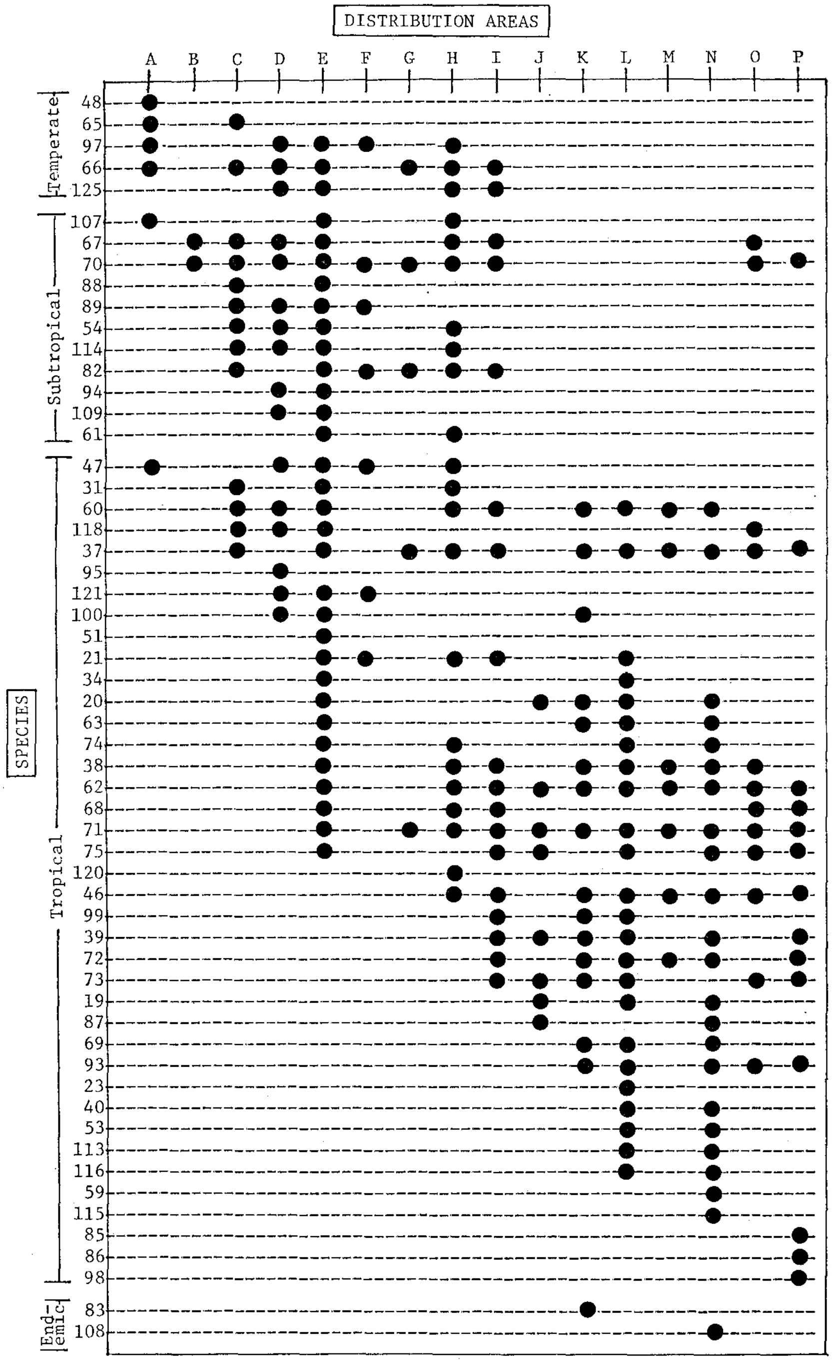
DISTRIBUTION AREAS
A B C D E F G H I J K L M N O P
SPECIES
Temperate
48
65
97
66
125
Subtropical
107
67
70
88
89
54
114
82
94
109
61
Tropical
47
31
60
118
37
95
121
100
51
21
34
20
63
74
38
62
68
71
75
120
46
99
39
72
73
19
87
69
93
23
40
53
113
116
59
115
85
86
98
End-emic
83
108

Fig. 8.

Group) (Fig. 8). However, as many as twenty-five species (from No. 47 to No. 73 in Fig. 8) extend their distribution ranges to the north of this line.

Line 3 is drawn between area N (the Yaeyama Group) and area O (Taiwan): Such subtropical species as Nos. 67 (*Pseudocentrotus depressus*) and 70 (*Anthocidaris crassispina*) found in Taiwan[2)] never occur in the areas from J (the Tokara Group) to N (the Yaeyama Group). The species of *Echinostrephus* found in areas O and P is No. 68 (*E. aciculatus*), while that found in area N is No. 69 (*E. molaris*). Nos. 85[3)] (*Clypeaster reticulatus*), 86 (*Arachnoides placenta*) and 98 (*Echinodiscus auritus*) found in area P (southern Taiwan) are not found in the east of this line (Fig. 8). Line 3 may be drawn more exactly between Chi-lung and Yonaguni Island.

By the above three lines, the whole region can be divided into the following four zoogeographical subregions:

1. Southern Korea Subregion: This region includes the southern part of the Korea Peninsula and the adjacent, small islands.

2. Kyushu Subregion: The main area is around the coast of Kyushu (the main island). The region extends as far north as the Tsushima Group and Cheju Island, as west as the Goto and the Danjo Groups, and as far south as the Koshiki and the Ohsumi Groups (to Yaku Island).

3. Ryukyu Subregion: The main area is around the Amami, the Okinawa, and the Yaeyama Groups. The range extends from the Tokara Group westward to the Yaeyama Group (to Yonaguni Island).

4. Taiwan Subregion: The region includes the coast of Taiwan. This subregion may be divided further into the northwestern and the southeastern Taiwan subregions.

In order to examine the faunal composition of these subregions, the faunal elements found in each subregion were counted and their percentages were calculated. The result is shown in Table 2.

Table 2. Faunal composition in the four zoogeographical subregions established for the intertidal & upper sublittoral region.
The numbers of species are parenthesized.

Element / Subregion	Temperate	Subtropical	Tropical	Endemic (uncertain)	Total
Southern Korea	66.7% (4)	16.7% (1)	16.7% (1)	0.0% (0)	100.0% (6)
Kyushu	10.0% (4)	27.5% (11)	62.5% (25)	0.0% (0)	100.0% (40)
Ryukyu	0.0% (0)	0.0% (0)	93.3% (28)	6.7% (2)	100.0% (30)
Taiwan	0.0% (0)	11.8% (2)	88.2% (15)	0.0% (0)	100.0% (17)
The whole region	8.8% (5)	19.3% (11)	68.4% (39)	3.5% (2)	100.0% (57)

2) The record of No. 67 in Taiwan was based on only a single specimen which had been collected at Chi-lung and was preserved at Kyushu University. No. 70 was commonly found at the shore of Chi-lung during my survey in 1975.

3) No. 85 is an ubiquitous species. Probably it will be found in the Yaeyama or the Okinawa Group in the future.

From Table 2, the characteristics of the fauna of each subregion are summarized as follows:

Southern Korea Subregion: Temperate elements dominate. Subtropical and tropical elements are rare.

Kyushu Subregion: Tropical elements dominate, however, the occurrences of a considerable number of subtropical elements together with a few temperate elements are notable.

Ryukyu Subregion: The fauna is completely tropical. Temperate and subtropical elements are absent.

Taiwan Subregion: Tropical elements dominate. A few subtropical elements occur. Temperate elements are absent.

The Lower Sublittoral Fauna

The localities where the specimens from the lower sublittoral zone were collected are shown in maps (Figs. 9–10) and in a table (Tab. 3).

The result of the specimen examination is shown as a table (Tab. 4).

The data in Table 4 were rearranged for the faunal analysis, and are shown as a figure of regional distributions of the lower sublittoral species (Fig. 11).

In order to examine the faunal composition of the areas in Figure 11, the faunal elements found in each area were counted and their percentages were calculated. The result is shown in Table 5.

It is suggested from Table 5 that the composition of the fauna of each area is not markedly different from each other, except that of the submarine banks, where a fairly high percentage of tropical element (77.8%) and a low percentage of subtropical element (22.2%) were found. It is also noteworthy that the temperate element is absent from the submarine banks and SE.-S. continental shelf.

For the comparison of the faunal relationship between these areas, the Nomura-Simpson's Coefficient (Nomura, 1939, 1940; Simpson, 1943; Kimoto, 1967) was used as an indication of the degree of relatedness of the fauna between two areas. It is calculated from Figure 11 by dividing the number of common species between two areas by the smaller number of species occurring in two areas. The result is shown in Table 6.

Roughly speaking, the values are not low throughout the table except those concerned with the submarine banks. It means that the faunas of the lower sublittoral zone are more or less closely related with each other except that of the submarine banks.

Considerablly high values are seen among the continental shelf areas and S. Kyushu shelf as follows:

N.-m.-NE. continental shelf & S. Kyushu shelf................................0.706
N.-m.-NE. continental shelf & SE.-S. continental shelf........................0.647
SE.-S. continental shelf & S. Kyushu shelf......................................0.600

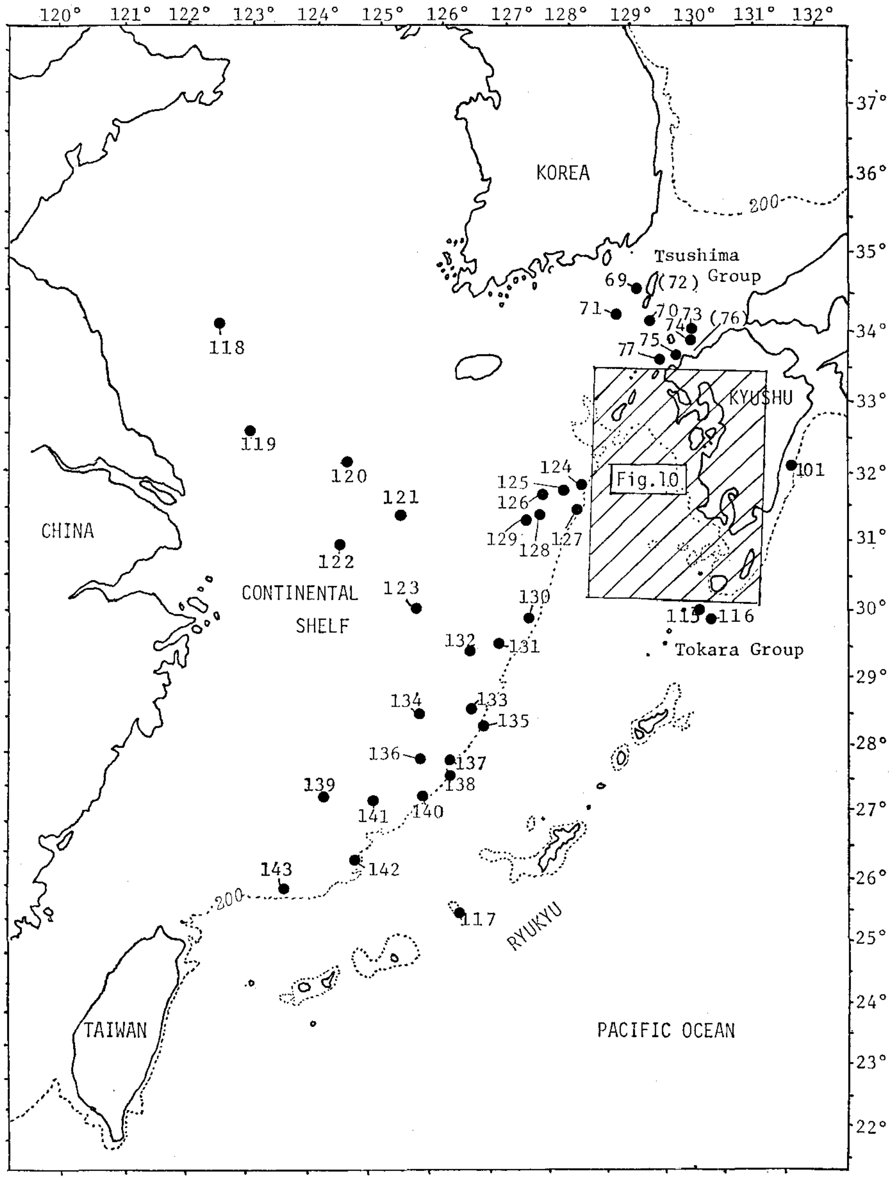

Figure 9. A map of the whole region showing the locations where the specimens from the lower sublittoral zone were collected. Data on each station are in Table 3.

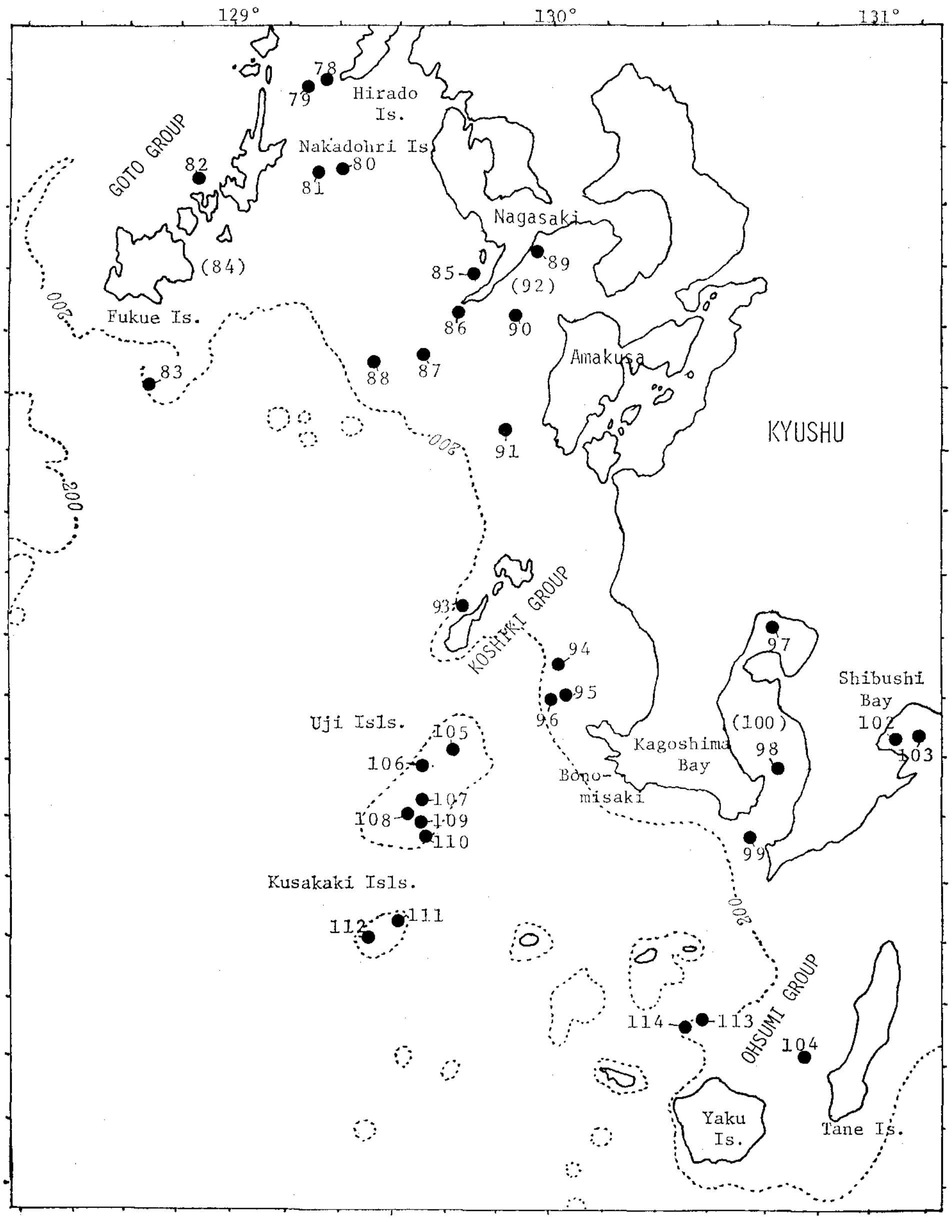

Figure 10. An enlarged map of southwestern Kyushu showing the locations where the specimens from the lower sublittoral zone were collected. Data on each station are in Table 3.

Table 3. The data on localities and depths of the stations in Figs. 9–10.

Station Number	Locality	Latitude N.	Longitude E.	Depth (m)
69	W. of Tsushima Isls.	34°25.3′	129°05.4′	150
70	S. of Tsushima Isls.	34°00.7′	129°19.4′	110
71	S. of Tsushima Isls.	33°59.4′	128°48.0′	102
72	off Tsushima Isls.L	uncertain		uncertain
73	E. of Iki Isl.	33°51.9′	130°00.1′	51
74	E. of Iki Isl.	33°45.1′	129°57.5′	45
75	S. of Iki. Isl.	33°30.5′	129°47.5′	38
76	off Fukuoka	uncertain		uncertain
77	N. of Hirado Isl.	33°25.6′	129°28.3′	61
78	S. of Hirado Isl.	33°09.4′	129°18.6′	83
79	S. of Hirado Isl.	33°08.2′	129°16.3′	56
80	E. of Nakadohri Isl.	32°55.0′	129°20.5′	56
81	E. of Nakadohri Isl.	32°54.7′	129°15.2′	49
82	W. of Nakadohri Isl.	32°54.0′	128°53.8′	82
83	S. of Fukue Isl.	32°21.5′	128°46:2′	180
84	off Goto Group	uncertain		uncertain
85	W. of Nagasaki	32°40.4′	129°46.5′	58
86	off Nomo	uncertain		uncertain
87	S.W. of Nagasaki	32°26.8′	129°34.0′	96
88	S.W. of Nagasaki	32°24.8′	129°24.7′	173
89	E. of Nagasaki	32°42.0′	129°57.6′	44
90	W. of Amakusa	32°31.2′	129°53.5′	77
91	W. of Amakusa	32°12.2′	129°50.2′	106
92	off Tomioka	uncertain		uncertain
93	W. of Koshiki Group	31°44.2′	129°42.4′	150
94	S.E. of Koshiki Group	31°35′	130°00′	150
95	S.E. of Koshiki Group	31°30′	130°00′	150–200
96	S.E. of Koshiki Group	31°29.2′	130°01.5′	196
97	Kagoshima Bay	31°40.2′	130°40.3′	145
98	Kagoshima Bay	31°17′	130°42′	126
99	Kagoshima Bay	31°05′	130°35′	150–200
100	Kagoshima Bay	uncertain		uncertain
101	N.W. of Miyazaki	32°00.3′	131°37.2′	48
102	Shibushi Bay	31°23′–25′	131°04′–12′	50
103	Shibushi Bay	uncertain		uncertain
104	W. of Tane Isl.	30°31.0′	130°48.5′	52–54
105	around Uji Isls.	31°21.7′	129°41.6′	119
106	around Uji Isls.	31°20.2′	129°35.3′	120

Table 3. (continued)

Station Number	Locality	Latitude N.	Longitude E.	Depth (m)
107	around Uji Isls.	31°13.2′	129°35.8′	150
108	around Uji Isls.	31°12.2′	129°31.8′	120
109	around Uji Isls.	31°11.1′	129°34.3′	136
110	around Uji Isls.	31°07.8′	129°32.3′	140
111	around Kusakaki Isls.	30°53.1′	129°30.5′	190–200
112	around Kusakaki Isls.	30°50.4′	129°24.4′	150–158
113	N. of Yaku Isls.	30°37.9′	130°29.0′	210
114	N. of Yaku Isls.	30°36.1′	130°26.2′	152–158
115	Tokara Strait	30°05.1′	130°05.1′	90–120
116	Tokara Strait	29°48.4′	130°11.4′	160–210
117	N.E. of Miyako Isl.	25°33′–34′	126°03′–04′	210
118	N.W. Cont. Shelf	33°35.3′	122°27.0′	32
119	N.W. Cont. Shelf	32°30.2′	123°02.0′	34
120	m. Cont. Shelf.	32°06.1′	124°34.9′	43
121	m. Cont. Shelf.	31°18.5′	125°19.2′	59
122	m. Cont. Shelf.	31°00.0′	124°21.4′	45
123	m. Cont. Shelf.	30°00.0′	125°29.5′	57
124	N.E. Cont. Shelf	31°46.6′	128°09.0′	154
125	N.E. Cont. Shelf	31°38.5′	127°55.2′	143
126	N.E. Cont. Shelf	31°35′	127°35′	100
127	N.E. Cont. Shelf	31°24.0′–24.9′	128°07.6′ –09.1′	150
128	N.E. Cont. Shelf	31°19.5′	127°32.0′	126
129	N.E. Cont. Shelf	31°15.5′	127°17.0′	120
130	S.E. Cont. Shelf	29°47.0′	127°30.0′	160–180
131	S.E. Cont. Shelf	29°28′–30′	127°12′–16′	125–133
132	S.E. Cont. Shelf	29°23.2′–23.7′	126°29.2′ –29.5′	97
133	S.E. Cont. Shelf	28°32.0′	126°18.8′	115
134	S.E. Cont. Shelf	28°32.0′	125°34.0′	101
135	S.E. Cont. Shelf	28°12′–13′	126°55′–56′	160–165
136	S.E. Cont. Shelf	27°52.6′	125°34.8′	109
137	S.E. Cont. Shelf	27°42′–45′	126°06′–08′	125
138	S.E. Cont. Shelf	27°33.9′	126°00.8′	135
139	S.E. Cont. Shelf	27°17.5′	124°00.0′	99
140	S.E. Cont. Shelf	27°16.0′	125°34.5′	115–118
141	S.E. Cont. Shelf	27°14.5′	124°45.0′	98
142	S. Cont. Shelf	26°15.7′–18.3′	124°30.0′ –32.8′	165–187
143	S. Cont. Shelf	25°47.7′–48.3′	123°47.5′ –51.6′	130

Table 4. Species occurrences at the localities in the lower sublittoral region.
As for the symbols, refer to Tab. 1.
*I-Korea Strait (Mortensen, 1928a) *II-off Kagoshima Bay (A. Agassiz and H.L. Clark, 1907b; Mortensen, 1928a)
*III-off Kagoshima Bay, 185–274 m (A. Agassiz and H.L. Clark, 1907b)
*IV-S.W. of the Tsushima Group (33°41′N, 128°50′E), 135 m (Mortensen, 1935)
*V-S.W. of the Goto Group, 170–190 m (A. Agassiz and H.L. Clark, 1907b)
*VI-Korea Strait, 106 m (A. Agassiz and H.L. Clark, 1907b)
*VII-Tsushima Strait (Mortensen, 1948d)
*VIII-near Amami-Ohshima Island (Döderlein, 1885)
*IX-?southeastern part of the continental shelf

Species	Localities (Sources of the data)
2	92(R), 94(P), 98(U), 99(P), 101(O), 125(O), 126(P), 132(V), 137(L), 140(M), *I
3	141(M)
4	83(N), 141(M), *II
6	138(M)
7	92(R), 99(P), 123(M), 130(O)
11	72(R), 76(R)
13	72(R), 117(L)
14	83(N), 92(N), 99(P), 109(M), 111(O), 125(O), 127(V)
15	125(O)
16	116(O), 137(L)
17	126(P), 136(O), 137(L)
18	107(O), 116(O)
19	115(O)
21	84(R), 87(N), 92(R), 103(R), 123(M), 143(L)
22	137(L)
29	70(M), 76(R), 95(P), 126(P), 127(V), 133(M),135(L), 137(L), 142(L)
30	99(P), 110(O)
35	103(R)
36	99(P), 120(M)
41	94(P)
43	107(O), 111(O), 138(M), *III
44	99(P), 105(M), 120(M), 132(V)
45	92(R), *IV
48	116(O), 122(M), 129(M)
49	69(M), 70(M), 71(M), 83(N), 92(R), 93(N), 96(M), 101(O), 102(P), 103(R), 106(O), 124(M), 128(M), 134(M), 140(M), 141(M)
50	70(M), 74(N), 88(M), 96(M)
52	94(P), 136(O), 140(M), 141(M)
55	70(M), 88(M), 92(R), 128(M), 139(M), 141(M)
56	*V
76	78(N)
77	107(O)
78	107(O)
79	70(M), 99(P), 107(O), 112(O), 116(O)
80	99(P)
81	99(P), 113(M), 125(O), 131(L), *VI
84	115(O)
90	*VII
91	87(N)
92	70(M), 93(N), 96(M), 114(O), 124(M), 140(M)
96	99(P), 108(O)
104	*VIII
105	87(N), 91(N), 93(N), 99(P), 125(O), 133(M)
106	*IX(Q)
107	92(R), 97(M), 104(O)
118	73(N), 81(N)
121	75(N), 80(N), 82(N)
122	115(O), 132(V)
123	80(N)
125	77(N), 79(N), 85(N), 89(N), 90(N), 100(U), 103(R), 118(M), 121(M)

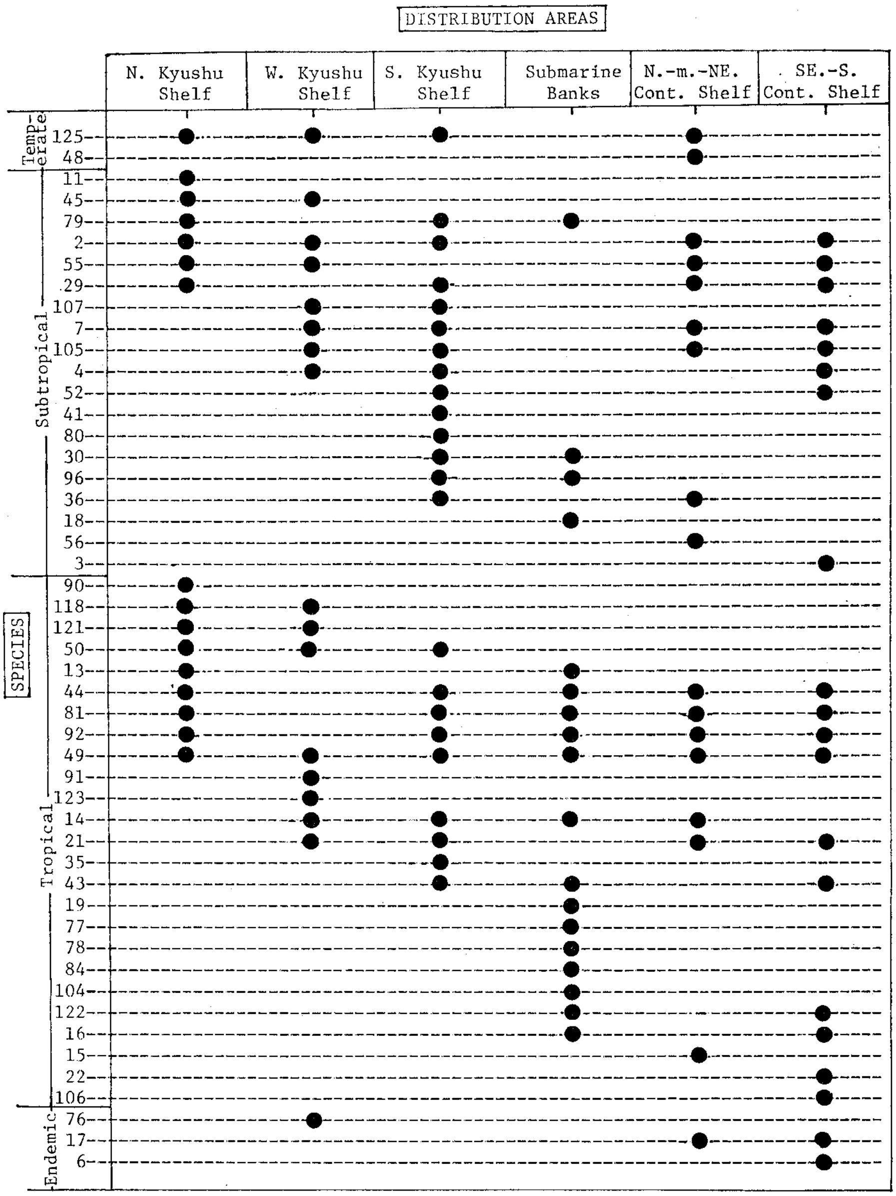

Figure 11. Regional distributions of the lower sublittoral species.
Species are shown by the species numbers given in the systematic list.
N. Kyushu Shelf, Sts. 69–77; W. Kyushu Shelf, Sts. 78–92; S. Kyushu Shelf, Sts. 93–104; Submarine Banks, Sts. 105–117; N.-m.-NE. Cont. Shelf, Sts. 118–129; SE.-S. Cont. Shelf, Sts. 130–143.

Table 5. Faunal composition in the areas of the lower sublittoral region. The numbers of species are parenthesized.

Area \ Element	Temperate	Subtropical	Tropical	Endemic (uncertain)	Total
N. Kyushu Shelf	6.3% (1)	37.5% (6)	56.3% (9)	0.0% (0)	100.0% (16)
W. Kyushu Shelf	5.9% (1)	41.2% (7)	47.1% (8)	5.9% (1)	100.0% (17)
S. Kyushu Shelf	4.3% (1)	56.5% (13)	39.1% (9)	0.0% (0)	100.0% (23)
Submarine Banks	0.0% (0)	22.2% (4)	77.8% (14)	0.0% (0)	100.0% (18)
N.-m.-NE. Cont. Shelf	11.8% (2)	41.2% (7)	41.2% (7)	5.9% (1)	100.0% (17)
SE.-S. Cont. Shelf	0.0% (0)	40.0% (8)	50.0% (10)	10.0% (2)	100.0% (20)
The whole area	4.1% (2)	38.8% (19)	51.0% (25)	6.1% (3)	100.0% (49)

Table 6. Nomura-Simpson's Coefficient between the areas in the lower sublittoral region. The numbers of common species between two areas are parenthesized.

	N. Kyushu Shelf	W. Kyushu Shelf	S. Kyushu Shelf	Submarine Banks	N.-m.-NE. Cont. Shelf
W. Kyushu Shelf	0.500 (8)				
S. Kyushu Shelf	0.563 (9)	0.588 (10)			
Submarine Banks	0.375 (6)	0.118 (2)	0.500 (9)		
N.-m.-NE. Cont. Shelf	0.500 (8)	0.471 (8)	0.706 (12)	0.294 (5)	
SE.-S. Cont. Shelf	0.438 (7)	0.353 (6)	0.600 (12)	0.389 (7)	0.647 (11)

Markedly low values which indicate the distant relationship are seen in the following areas:

Submarine banks & W. Kyushu shelf..0.118
Submarine banks & N.-m.-NE. continental shelf...............................0.294
W. Kyushu shelf & SE.-S. continental shelf.......................................0.353
Submarine banks & N. Kyushu shelf..0.375
Submarine banks & SE.-S. continental shelf.....................................0.389

The Bathyal Fauna

The localities where the specimens from the bathyal zone were collected are shown in a map (Fig. 12) and in a table (Tab. 7).

The result of the specimen examination is shown as a table (Tab. 8).

Based on the data in Table 8, the vertical and the regional distributions of the bathyal species are shown as a figure (Fig. 13).

From Figure 13, the ratio of the Japanese (excluding the endemic; Nos. 1, 33, 129 in Fig. 13) and the ubiquitous elements within each vertical zone are counted as follows:

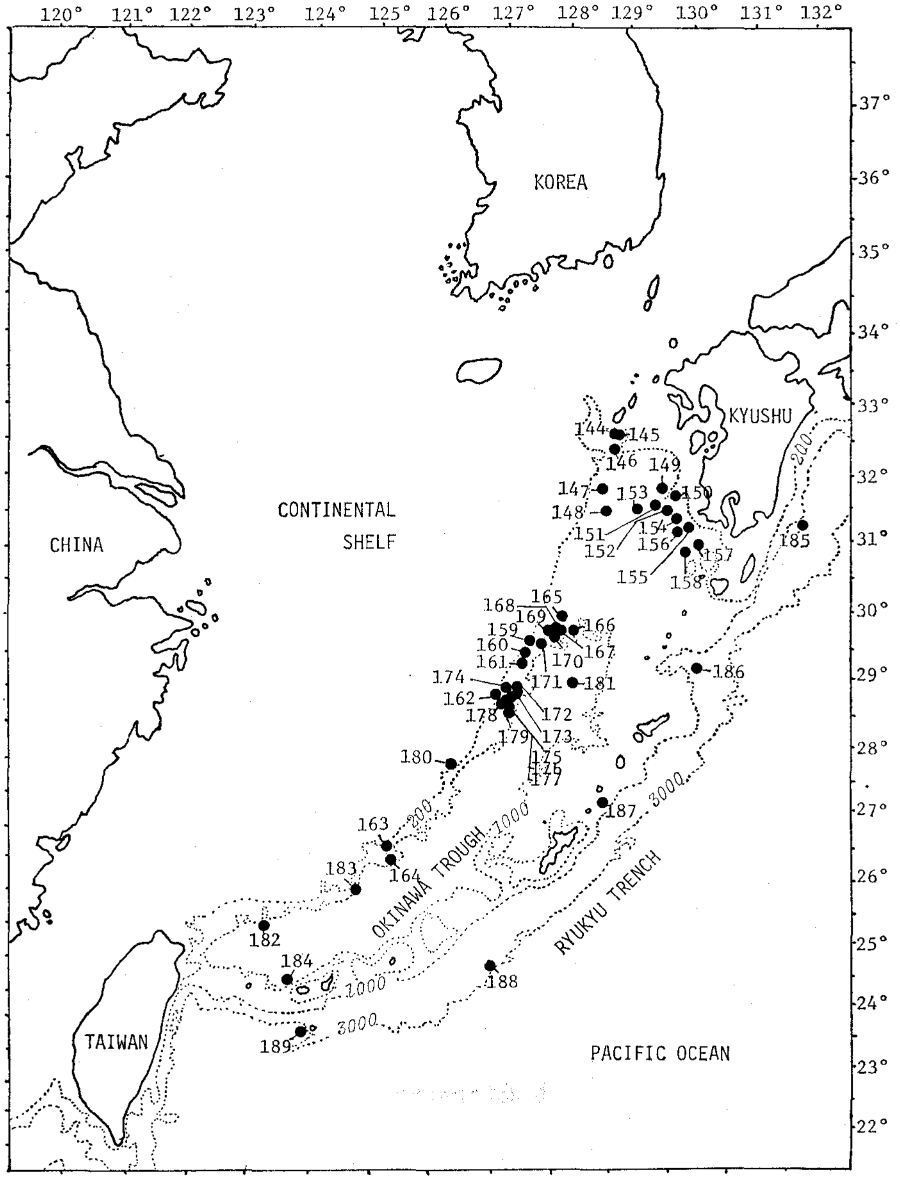

Figure 12. A map of the whole region showing the locations where the specimens from the bathyal zone were collected. Data on each station are in Table 7.

Table 7. The data on localities and depths of the stations in Fig. 12.

Station Number	Locality	Latitude N.	Longitude E.	Depth (m)
144	S. of Fukue Isl.	32°25.5′	128°42.7′	230
145	S. of Fukue Isl.	32°25.5′	128°42.7′	238
146	S. of Fukue Isl.	32°11.4′	128°44.9′	318
147	S.E. of Danjo Isls.	31°38.0′	128°28.0′	470
148	S.E. of Danjo Isls.	31°18.3′	128°35.4′	460–512
149	W. of Koshiki Isls.	31°44.1′	129°41.5′	280
150	E. of Koshiki Isls.	31°39′	129°51′	350
151	S. of Koshiki Isls.	31°35′	129°42′	380
152	S. of Koshiki Isls.	31°31.9′	129°47.9′	580
153	S.W. of Koshiki Isls.	31°31.0′	129°21.0′	730–740
154	W. of Bono-misaki	31°18.1′	129°53.4′	310
155	W. of Bono-misaki	31°13.6′	129°58.4′	295–300
156	W. of Bono-misaki	31°09′	129°51′	350
157	S.W. of Bono-misaki	30°53.4′	130°07.0′	372
158	S.W. of Bono-misaki	30°44.6′	129°55.3′	425
159	S.E. Cont. slope	29°25.4′–27.3′	127°19.6′–21.1′	208–210
160	S.E. Cont. slope	29°19′	127°19′	255–260
161	S.E. Cont. slope	29°11′–16′	127°11′–17′	300–310
162	S.E. Cont. slope	28°37.0′	126°56.0′	285–430
163	S. Cont. slope	26°33.2′–34.4′	125°04.9′–05.9′	260–280
164	S. Cont. slope	26°21.0′–23.3′	125°04.0′–00.7′	295–385
165	N.-W. Okinawa Trough	29°57′–58′	128°00′–02′	585–615
166	N.-W. Okinawa Trough	29°43.8′–47.1′	128°26.8′–27.1′	990–1,050
167	N.-W. Okinawa Trough	29°44′	128°03′	815
168	N.-W. Okinawa Trough	29°44′–46′	127°57′–59′	710–713
169	N.-W. Okinawa Trough	29°43′–44′	127°37′–40′	410–423
170	N.-W. Okinawa Trough	29°42′–44′	127°48′–49′	495–510
171	N.-W. Okinawa Trough	29°23.0′–24.5′	127°30.9′–32.0′	642–650
172	N.-W. Okinawa Trough	28°53′–55′	127°18′–19′	820–830
173	N.-W. Okinawa Trough	28°50′–51′	127°14′–16′	700–740
174	N.-W. Okinawa Trough	28°48.2′–49.8′	127°03.7′–05.5′	425–440
175	N.-W. Okinawa Trough	28°45′–47′	127°07′–08′	530–542
176	N.-W. Okinawa Trough	28°42′–46′	127°09′–10′	500–535
177	N.-W. Okinawa Trough	28°40′–43′	127°12′–14′	750–755
178	N.-W. Okinawa Trough	28°34′–36′	127°09′–12′	800–910
179	N.-W. Okinawa Trough	28°26.8′–28.2′	127°07.5′–09.8′	1,000
180	N.-W. Okinawa Trough	27°45.5′–46.0′	126°16.5′–17.0′	490–500
181	m. Okinawa Trough	28°38.9′	128°12.5′	1,130
182	S. Okinawa Trough	25°37.7′–37.1′	122°53.1′–53.6′	560–692
183	S. Okinawa Trough	25°17.1′–26°15.7′	124°46.8′–47.4′	910–990
184	S. Okinawa Trough	24°15′	123°30′	400
185	off S.E. Kyushu	31°12.0′	131°42.4′	1,125
186	Tokara Strait	29°13.7′	129°59.6′	1,240
187	E. of Yoron Isl.	27°06.7′–06.8′	128°41.8′–41.9′	870–945
188	E. of Miyako Isl.	24°43.4′–47.0′	126°26.3′–28.0′	1,675–1,710
189	S. of Iriomote Isl.	23°41.3′–42.3′	123°45.2′–45·8′	3,436–3,452

Table 8. Species occurrences at the localities in the bathyal region.
As for the symbols, refer to Tab. 1.
*I-S.W. of Bono-misaki, 360 m (Mortensen, 1928b)
*II-off Kagoshima Bay, 274 m (A. Agassiz and H.L. Clark, 1907b)
*III-off the Goto Group (Mortensen, 1943a)
*IV-S.W. of the Koshiki Group, 664–769 m (A. Agassiz and H.L. Clark, 1907b)
*V-S.W. of the Koshiki Group, 704 m (A. Agassiz and H.L. Clark, 1907b)
*VI-S.W. of the Koshiki Group, 704–1,296 m (A. Agassiz and H.L. Clark, 1907b)
*VII-S.W. of the Koshiki Group, 704–781 m (A. Agassiz and H.L. Clark, 1907b)
*VIII-off Kagoshima Bay, 792m (A. Agassiz and H.L. Clark, 1907b)

Species	Localities (Sources of the data)
1	148(V), 154(M), 165(L), 170(L), 174(L), 176(L), 180(L)
5	155(O), 162(M), 169(L)
8	150(P), 160(L), 161(L)
9	150(P), 154(M), 162(M)
10	*I
12	184(R)
14	145(N), 146(N), 154(M), 159(L), 163(L)
18	184(R)
24	153(O), 157(M), 170(L), 173(L), 175(L), 177(L), 179(V), 180(L), 183(L), 188(V)
25	188(V), 189(V)
26	186(O)
27	157(M), 166(L), 185(O)
28	164(L), 167(L), 169(L), 171(L), 182(L)
32	187(V)
33	151(P)
41	144(N)
42	170(L)
57	*II
58	*III
64	152(N), 166(L), 185(O), 186(O)
92	149(N)
101	156(P), 157(M), 158(M)
102	*IV
103	*V
105	145(N), 149(N)
110	*V
111	*IV
112	181(O), 187(V)
117	150(P)
119	147(N)
124	179(V)
126	172(L), 178(L), 179(V)
127	*VI
128	*VII
129	*VIII

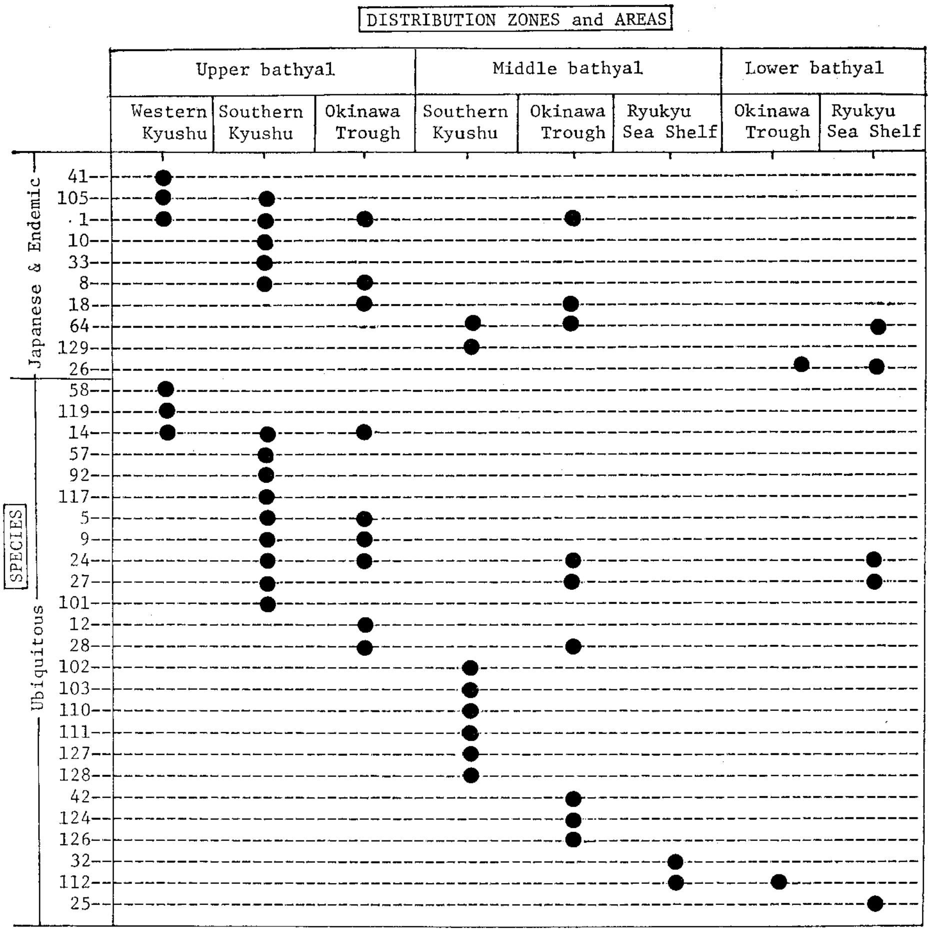

Figure 13. The vertical and regional distributions of the bathyal species.
Species are shown by the species numbers given in the systematic list.
Upper Bathyal, 200–500 m depths; Middle Bathyal, 500–1,000 m depths; Lower Bathyal, 1,000–3,500m depths.
Western Kyushu, Sts. 144–148; Southern Kyushu, Sts. 149–158; Okinawa Trough, Sts. 159–184; Ryukyu Sea Shelf, Sts. 185–189.

Zone	Japanese	Ubiquitous
Upper bathyal	5 sp. (27.8%)	13 sp. (72.2%)
Middle bathyal	2 sp. (12.5%)	14 sp. (87.5%)
Lower bathyal	2 sp. (33.3%)	4 sp. (66.7%)
The whole bathyal	7 sp. (21.9%)	25 sp. (78.1%)

It is notable that the ratio of the ubiquitous elements is markedly high throughout the bathyal zones. It will be much higher by findings of new localities for the Japanese and the endemic elements.

Discussion

The faunal characteristics of the four zoogeographical subregions established for the intertidal & upper sublittoral region may be explained fairly well from the hydrography of the East China Sea and its adjacent waters. The Ryukyu subregion where the fauna is purely tropical is bounded by the Kuroshio to the west and north. Throughout this subregion, the mean temperatures in the water shallower than a depth of 100 m do not fall below 20°C even in winter (Japan Oceanographic Data Center, 1978). The Kyushu subregion is always under the influence of the large and small branches of the warm currents. These carry many larvae of tropical species there. The occurrences of a fair number of subtropical species in this subregion are mainly attributable to the warm water of Kuroshio, while those of a considerable number of temperate species are attributable to the less warm coastal water of Kyushu. The Southern Korea subregion is surrounded by the cold coastal water of the Korea Peninsula, and it may explain the temperate fauna occurring there. The Taiwan subregion may be divided further into the northwestern and southeastern subregions. The former receives the coastal water of the Chinese Continent to some extent and the latter is completely within the Kuroshio area.

The faunal differences on the north and south sides of the Line 1 have been reported in distributional studies of caprellids (Arimato, 1973) and molluscs of the genus *Haliotis* (Uchida and Yamamoto, 1942).

The Line 2 between the Ohsumi and the Tokara Groups is a well-known zoogeographical line, the Watase's Line, which separates the Palaearctic and the Oriental region. It was originally drawn for land-dwelling animals, but it seems to be also valid for such marine animals as cirripedians (Utinomi, 1955), some bottom-dwelling fishes (Kuroda, 1955), brachiopods (Nomura and Hatai, 1936), and shells (widely known among Japanese conchologists). For land faunas, this line exists as a reflection of the geological history. However, for marine faunas, the line seems to exist as a reflection of hydrography around it. The main stream of the Kuroshio flowing just along this line eastward seems to be an effective barrier against the southward distribution of the temperate and subtropical species.

It is interesting that such common intertidal species as *Anthocidaris crassispina, Pseudocentrotus depressus,* and *Echinostrephus aciculatus* occur discontinuously on the north side of the Line 2 and on the west side of the Line 3.

The faunal differences on the east and west sides of the Line 3 have not been adequately investigated, although a marine zoogeographical line has been drawn nearly the same location as the Line 3 by Utinomi (1955) in his distributional study on the cirripedians.

In the preceding chapters, I was not concerned with the fauna of the Chinese coast, where the water is in general shallower than 50 m, and the fauna seems to be rather poor. In Table 9, the species known from the Chinese coastal waters connected with the East China Sea (from Chekiang to Fukien, and Taiwan Strait) are listed together with their localities based on Chang (1932), Chang *et al.* (1964), and

Table 9. Echinoids of the Chinese coastal waters connected with the East China Sea (from Chekiang to Fukien and the Taiwan Strait).
Compiled from Chang (1932) and Chang *et al.* (1964), and revised specially for this paper by Dr. Y. Liao of the Institute of Oceanography, Academia Sinica, People's Republic of China in 1979.

Species	Localities
Temnopleurus toreumaticus (LESKE)	Chekiang-Fukien
Temnopleurus hardwickii (GRAY)	Chekiang and Taiwan Strait
Temnopleurus reevesii (GRAY)	Chekiang-Fukien
Temnotrema sculptum (A. AGASSIZ)	Chekiang-Fukien and Taiwan Strait
Hemicentrotus pulcherrimus (A. AGASSIZ)	Chekiang-Fukien
Anthocidaris crassispina (A AGASSIZ)	Chekiang-Fukien
Arachnoides placenta (LINNAEUS)	Fukien
Fibulariella acuta (YOSHIWARA)	Chekiang-Fukien and Taiwan Strait
Peronella lesueuri (L. AGASSIZ)	Fukien
Laganum depressum (LESSON)	Taiwan Strait
Schizaster lacunosus (LINNAEUS)	Chekiang
Lovenia elongata (GRAY)	Fukien
Lovenia triforis (KOEHLER)	Chekiang

personal information from Dr. Y. Liao (1979).

It is worthy of notice that such species common in Kyushu as *Anthocidaris crassispina* and *Hemicentrotus pulcherrimus* also occur commonly in the Chinese coasts, and such species as *Arachnoides placenta, Peronella lesueuri,* and *Laganum depressum* which do not occur in Kyushu occur in the Chinese coasts. It is also suggested from Chang *et al.* (1964) that temperate species such as *Strongylocentrotus nudus* and *Echinocardium cordatum,* and a subarctic species such as *Glyptocidaris crenularis* occur in the north of Shantung on the Yellow Sea side, and many tropical species occur in the south of Kwangtung on the South China Sea side. Although the data are too few to discuss the fauna of the Chinese coast, the ratio of the temperate, the subtropical, and the tropical elements in the area connected with the East China Sea are: 15.4% (2 sp.); 23.1% (3 sp.); 61.5% (8 sp.).

With regard to the lower sublittoral fauna, the present study revealed that the faunas on the insular shelves of Kyushu and those on the continental shelf are closely related with each other. It is evident that the Kuroshio exerts influence on Kyushu shelves and on the southern to northeastern areas of the continental shelf. The high percentage of tropical species in the submarine banks area apparently indicates a strong influenceof the Kuroshio on the area. Okutani (1963, 1972) has also reported the strong influence of the Kuroshio on the molluscan fauna of the submarine banks around southern Kyushu and Izu-Shichito Islands.

The benthic surveys in the East China Sea have been carried out by Matsui and Taki (1950), Matsui (1951), Horikoshi *et al.* (1971), and Yamashita (1961, 1977a, 1977b, 1977c, 1978, 1979a, 1979b). In the studies on anomurans, Yamashita (1977a, 1977b) stated that such subarctic (Okhotsk-Bering) species as *Pagurus ohotensis* and *Pagurus pectinatus* occur abundantly in the Yellow Sea but never in the East China Sea which spreads south of the line drawn from Cheju Island to Shanghai. He stated further that a temperate species, *Dardanus impressus*, which does not occur in the former sea abundantly occurs in the latter. Similar patterns of distribution can be seen in his ecological studies on polychaetes (Yamashita, 1977c) which lists 104 species, on molluscs (Yamashita, 1978) with 172 species, on brachyurans (Yamashita, 1979a) with 92 species, and on echinoderms (Yamashita, 1979b) with about 61 species.

The present study reveals that the subarctic elements are completely absent from the whole region. Jensen (1974) recently cited "off Nagasaki" (probably the lower sublittoral zone) as one of the localities of an arctic (or subarctic) species, *Strongylocentrotus pallidus* (Sars), however, this is difficult to accept because the water off Nagasaki is under the influence of the Tsushima current and too warm to permit the occurrence of such an arctic species. One possible exception is a rather ubiquitous species, *Echinocardium cordatum* which occurs also in subarctic seas. It was defined as a temperate element in the present study because of its common occurrences in temperate waters.

In the present paper, new localities have been reported for many species without special notice. For example, *Sperosoma giganteum* (St. 186, Ryukyu sea shelf) has not been known outside the water off central Japan, and *Kamptosoma asterias* (Sts. 188 and 189, Ryukyu sea shelf) has been known only from two localities in the South and Central Pacific.

The number of echinoid species in the world seas may be estimated about 830 and about 165 in Japanese waters (Shigei, 1974). On that basis the 129 species recorded in this paper constitute 15.2% of the total from the world seas and 78.2% of the Japanese species. These values indicate that the echinoid fauna of the present region is extremely rich.

Additional Remarks

Several species which have been reported by other workers from the localities within the present region were not included in the present paper. Such species and the reasons for exclusion are as follows:

Order Echinoida

Suborder Temnopleurina

Family Temnopleuridae

Printechinus impressus Koehler was reported from off "Nakanokami-shima" which probably means Nakanougan-jima Isl., the Yaeyama Group, at a depth of 400 m by Ikeda (1940) who, however, showed neither figures nor descriptions. I think his identification is not reliable. This species has hitherto been known only from the Andaman Sea at depths of 110–135 m.

Desmechinus anomalus H.L. Clark was reported by H.L. Clark (1923) from the type locality designated as "China Sea" which may mean the South China Sea, Chinese coast, or even Yellow Sea.

Microcyphus maculatus A. Agassiz was stated to occur at Amami-Ohshima Isl. by Yoshiwara (1898), however, it is probably his misidentification as mentioned by Mortensen in his monograph (1943a, p. 155) "If Yoshiwara has had specimens from Riukiu (=Amami-Ohshima Isl.) before him, he has almost certainly misidentified them; as the species *maculatus* is known with certainty only from Mauritius; it is very unlikely that it should reappear at Japan". Although Hayasaka (1948) also reported its occurrence at Kao-hsiung, Taiwan based on his "strongly worn away" specimen (p. 29) with a figure, from which however, the species cannot be identified.

Microcyphus zigzag A. Agassiz was stated to occur at Kagoshima by Yoshiwara (1898). This is also probably an error in identification as mentioned by Mortensen (1943a, p. 171) "If he had specimens from there, it is no doubt a misidentification". This species has been known with certainty only from south Australia and Tasmania.

Suborder Echinina

Family Echinometridae

Heterocentrotus trigonarius (Lamarck) was stated to occur at Hungtouhsu, Taiwan by Hayasaka (1948), however, his description rather clearly indicates that his specimens are those of *H. mammillatus* with tapering spines.

Order Cassiduloida

Suborder Neolampadina

Family Neolampadidae

Anochanus sinensis Grube has been known by a single specimen from a vague, type locality, "China Sea".

Order Clypeasteroida

Suborder Laganina

Family Fibulariidae

Fibularia ovulum trigona Lamarck was stated to occur in Korea Strait by Mortensen (1948). I think his specimen probably belongs to *Fibularia* n. sp. of the present paper.

Fibularia volva A. Agassiz was stated to occur in "Channel of Formosa" by A. Agassiz (1872–74) and also in Taiwan by Yoshiwara (1900), however, I think these localities are unreliable as have been pointed out by Mortensen (1948a, P. 214).

Echinocyamus (Mortonia) australis (Desmoulins) was stated to occur in Formosa Sea by Nishiyama (1966) who, however, neither figured nor described specimens at all. The only locality hitherto known with certainty is Hawaii.

Family Laganidae

Laganum putnami A. Agassiz, probably a synonym of *L. depressum*, was stated to occur at "Oushima" by A. Agassiz (1872–74) and H.L. Clark (1914).

Laganum depressum Lesson was stated to occur at Amami-Ohshima Isl. and Taiwan by Yoshiwara (1900), however, I think he misidentified *Peronella lesueuri* as this species.

Laganum decagonalis Lesson was stated to occur at Kagoshima and Taiwan by Yoshiwara (1900), however, his *L. decagonalis* from Kagoshima is apparently *Peronella japonica* and that from Taiwan might be *Peronella lesueuri*.

Peronella orbicularis (Leske) was stated to occur in Taiwan by Yoshiwara (1900). It is quite unreliable.

Peronella minuta (Meijere) was stated to occur in Kagoshima Bay by Nishiyama (1966), but he showed neither figures nor descriptions. I did not find this species during the present investigation.

Family Astriclypeidae

Echinodiscus auritus siamensis Mortensen was stated to occur in "southern Japan and Formosa" by Nishiyama (1966) who probably noted it based on Hayasaka (1948).

Order Spatangoida

Suborder Spatangina

Family Schizasteridae

Periaster fragilis A. Agassiz and H.L. Clark, or *Hypselaster fragilis* (A. Agassiz and H.L. Clark) is a vague species which was described from a single, immature specimen from off the Koshiki Group at a depth of 715 m (A. Agassiz and H.L. Clark, 1907b). About this species, Mortensen mentioned (1951, p. 321) "The only specimen known being a young one, still without genital pores, it is really quite unidentifiable. There is no certainty at all that it is a *Hypselaster;* but the statement that below the periproct there is a faint indication of an anal fascilole indicate that it is a Schizasterid".

Family Spatangidae

Spatangus altus Lütken has been known from a vague, type locality "China Sea".

Spatangus pallidus H.L. Clark was stated to occur in "off Kyushu" by Nishiyama (1966), but it is uncertain that he really examined the specimens. I did not find this species during the present investigation.

Spatangus luetkeni A. Agassiz was stated to occur in Taiwan by Yoshiwara (1900). Further information will be needed.

Maretia tubderculata A. Agassiz and H.L. Clark is uncertain species which was described based on a single, immature specimen from Korea Strait at a depth of 108 m. It may belong to *Lovenia* rather than to *Maretia* as Mortensen has stated (1951, p. 45).

Family Loveniidae

Lovenia subcarinata (Gray) was stated to occur in Kagoshima Bay by Yoshiwara (1900), however, it is unreliable. He reproduced A. Agassiz's figures when he figured this species in his "Japanese Echini".

Pseudolovenia hirsuta A. Agassiz and H.L. Clark was reported by A. Agassiz and H.L. Clark (1907b) from off the Koshiki Group at depths of 664–731 m. Mortensen stated (1951, p. 127) "The identification is not beyond doubt, the specimens being young, so that for the present, at least, we are not entitled to state that it occurs also in Japanese seas".

Family Asterostomatidae

Palaeotrema loveni (A. Agassiz) was stated to occur in Kagoshima Bay by Nishiyama (1966). It is probable that he noted the locality without examination of the specimens. His source of information is unknown.

Summary

1. 112 echinoid species were found from the East China Sea and the coastal waters of Southern Korea, Kyushu, Ryukyu, and Taiwan through my examination of specimens collected by various workers from 189 localities in depths of 0–3,452 m. An additional 17 species reported in the past was added to them and the faunal study was made based on distributional data of a total of 129 species.

2. For the intertidal & upper sublittoral region, the following three zoogeographical lines, and four subregions were established:

Lines; 1–between the Korea Peninsula and the Cheju Island-Tsushima Group, 2–between the Ohsumi Group and the Tokara Group, and 3–between the Yaeyama Group and Taiwan.

Subregions; 1–Southern Korea, 2–Kyushu, 3–Ryukyu, and 4–Taiwan.

In these subregions, tropical elements dominated except in Southern Korea. They were found in increasing order in Southern Korea, Kyushu, Taiwan, and Ryukyu where the fauna was completely tropical. Subtropical elements were found in increasing order in, Southern Korea, Taiwan, and Kyushu, but not in Ryukyu. Temperate elements were not found in Taiwan and Ryukyu.

3. The lower sublittoral fauna was rather uniform throughout the whole region except the submarine banks, where tropical elements dominated distinctly and the fauna was fairly unique.

4. The bathyal fauna had a high ratio of ubiquitous elements.

5. No subarctic elements were found throughout the faunas.

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