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EUPHAUSIIDS OF SOUTHEAST ASIAN WATERS

by

Edward Brinton

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Edward Brinton *

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PACIFIC OCEAN

INDIAN OCEAN

EAST CHINA SEA

PHILIPPINE SEA

SOUTH CHINA SEA

GULF OF THAILAND

ANDAMAN SEA

STRAIT OF MALACCA

SUNDA SHELF

JAVA SEA

SULU SEA

CELEBES SEA

MAKASSAR STRAIT

MOLUCCA SEA

FLORES SEA

HALMAHERA SEA

CERAM SEA

BANDA SEA

SAVU SEA

TIMOR SEA

ARAFURA SEA

TORRES STRAIT

BISMARCK SEA

SOLOMAN SEA

CORAL SEA
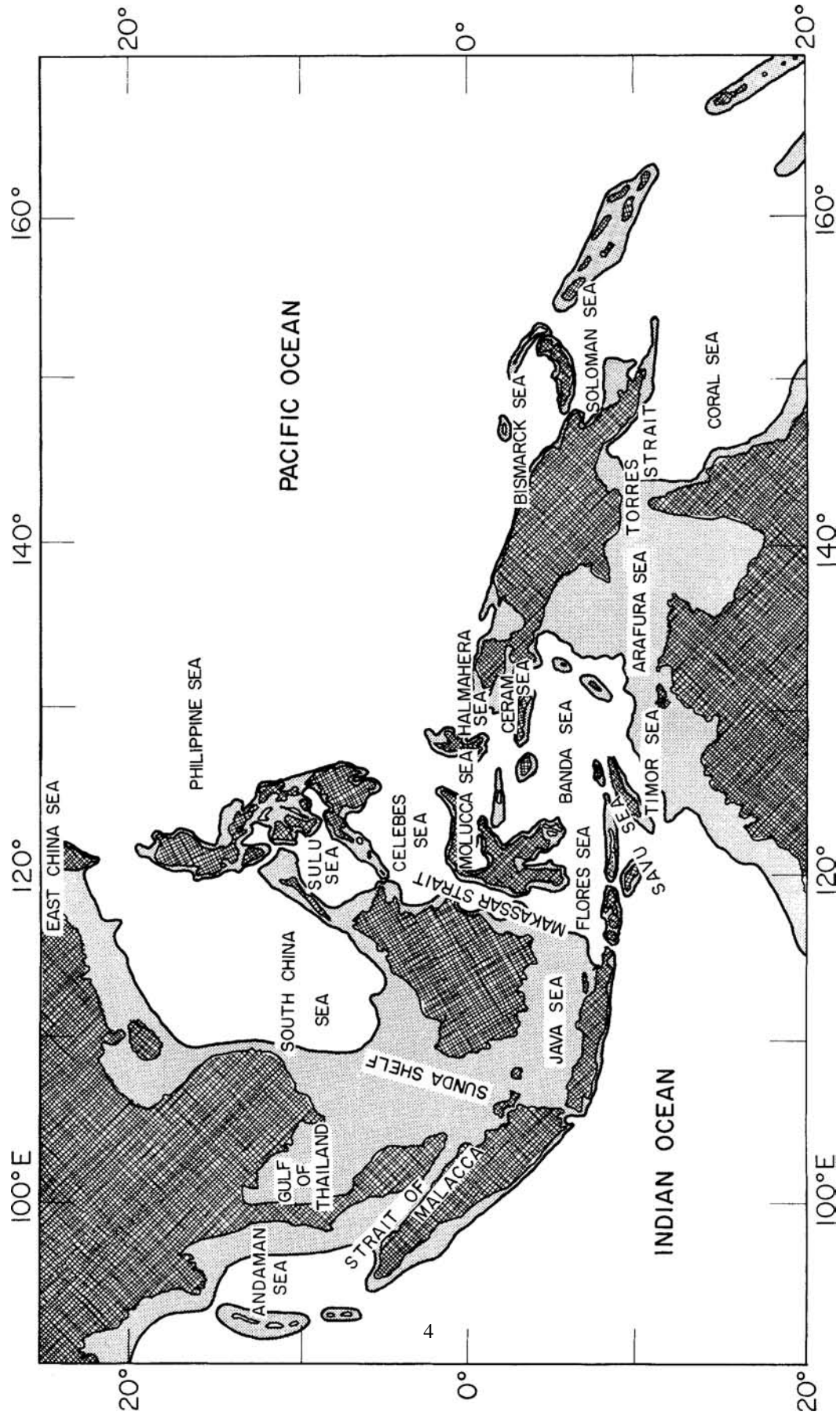
Shelves and Basins of the Austral-Asian Seas

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ABSTRACT

Euphausiids collected by R/V *Stranger* during 1959-61 were examined with respect to 1) seasonal change in distribution, abundance and recruitment in the Gulf of Thailand and South China Sea and 2) range through the Indo-Australian seas.

Discussion of the species is preceded by a description of the distribution of zooplankton biomass. In the Gulf of Thailand, biomass was found to be three to five times greater than in the open South China Sea. In eastern waters of the Gulf, the peak appeared during the intermonsoon period following northeast winds. The western and northern parts of the Gulf were richest under the influence of the southwest monsoon. Northern coastal waters of South Viet Nam were richest toward the end of each season: 1) the northeast monsoon when coastal upwelling and southerly flow from the Gulf of Tonkin took place and 2) the southwest monsoon season of northerly flow. The southern shelf and the basin region of the South China Sea yielded the greatest biomass during the southwest monsoon season when flow was from the direction of adjacent neritic waters to the southwest.

The Sunda Shelf waters, including the Gulf of Thailand, constitute the extensive neritic province in which *Pseudeuphausia* lives. The South China Sea basin, though the largest basin in the inter-ocean region, essentially a cul-de-sac with respect to its oceanic euphausiid assemblage, the species of which are derived from both the tropical and subtropical Pacific to the northeast. They are transported southwestward as far as the Sunda Shelf. During the northeast monsoon season many of the oceanic species tend to extend into shelf waters. Evidently the presence over the shelf of a dense neritic plankton, together with the shallowness of the water which prevents the normal range of euphausiid vertical migration, precludes presence of the oceanic species. Only *Stylocheiron* species, which do not migrate vertically, extend much beyond the edge of the shelf, rarely entering the Gulf of Thailand.

The taxonomic diversity of the predominant species of the South China Sea (each belongs to a different species group) indicates that this assemblage is part of a regional plankton community.

The annual reproductive cycles of the oceanic species were like that of neritic *Pseudeuphausia*, with larvae produced year-round but with maximum spawning taking place during, and at the end of, the northeast monsoon season. Production of *Pseudeuphausia* in the Gulf of Thailand shifted seasonally from southwest to northeast, evidently in response to coastal enrichment processes initiated by southwest and northeast monsoon winds respectively. Of the parameters measured, only low salinity (<31 ‰) correlates with the paucity of larvae.

Local occurrences of the species are considered in relation to the global distributions in a study of the effectiveness of the inter-ocean seas in maintaining or interrupting flow between Pacific and Indian Ocean populations and in providing local habitats. The pelagic connection between the two oceans is limited to succession of deeper seas: Celebes-Molucca-Banda and Flores-Timor. The large number (46) of euphausiid species in this inter-ocean region apparently reflects complexity in the oceanography rather than in the plankton community. Regularly occurring species are either endemic (e.g. *Stylocheiron insulare*), Indo-Pacific equatorial (e.g. *Euphausia diomedeae*) or broadly ranging warm-water cosmopolites (e.g. epipelagic *Stylocheiron carinatum* and mesopelagic *Nematobrachion boöpis*). Species associated primarily with central water masses of the Indian and Pacific Oceans are sparse though seasonally consistent in occurrence.

The most widely-ranging species in the global sense (e.g. *Nematobrachion boöpis, Stylocheiron carinatum*) exhibit inter-oceanic and inter-hemispheric continuity that appears to have long been firmly established. These species do not have close relatives, with the exceptions *Stylocheiron longicorne* and *S. maximum*, each member of a sub-generic species group. This suggests that the speciation process (population isolations re-invasions) in *Stylocheiron*, a genus consisting of members which do not migrate vertically, each occupying a discrete depth interval, may differ from that process in strongly migrating genera such as *Euphausia* and *Thysanopoda*.

The importance of the Indo-Australian region in the evolution of sub-tropical and tropical species is indicated by 1) the large number of species found there, 2) the present partitioning of central water mass species distributions (e.g. *Euphausia brevis* exists globally in five sub-populations), and of Indo-Pacific equatorial distributions (*E. paragibba* exists in separated Pacific and Indian Ocean populations), 3) the patchy confluence of some central and subtropical species through this waterway (e.g. *E. mutica*), and 4) the existence of Indo-Australian endemics (e.g. *E. fallax, E. sanzoi, Nematoscelis lobata*).

The species of the region, including larval stages of most South China Sea species, are illustrated and briefly described. *Thysanopoda subaequalis* Boden is synonymized with *T. aequalis* Hansen, the type material of *T aequalis* having been found to possess the characteristics defining *T. subaequalis*. The species presently called *T. aequalis* is redescribed as *T. astylata*. A third geographical form of *Stylocheiron longicorne* is described as the "North Indian Ocean Form."

INTRODUCTION

The Austral-Asian seas are a series of connected epicontinental habitats, forming the only existing low-latitude inter-ocean pathway for pelagic organisms. They sustain both neritic and oceanic populations, transient, cosmopolitan and endemic. The geographical complexity of the region, together with its diverse climate and bathymetry, has led to the emergence of local habitats for planktonic species. Certain of these are the most restricted to be found in the world ocean. The seas serve also as population centers within the ranges of circumglobal tropical species. Thus the region may act concurrently as a passageway, barrier and independent habitat, depending upon the species. The role it plays as speciation catalyst for its planktonic inhabitants was touched upon earlier (Brinton, 1964). It will be considered further here.

This study is concerned primarily with distribution, seasonal variation in abundance and recruitment, and taxonomy of southeast Asian crustaceans belonging to the order Euphausiacea. The material was collected by the Naga expedition, carried out jointly by Thailand, South Viet Nam and the U.S.A. During the 2 1/2 years of the expedition, 1959-61, the research vessel *Stranger* of the Scripps Institution of Oceanography was engaged in a series of cruises in the Gulf of Thailand and the South China Sea, obtaining physical-chemical data and biological collections for studies of the marine environment adjacent to Thailand and the Indo-Chinese peninsula.

Cruises alternated between two survey areas: the Gulf of Thailand (odd numbered cruises S-1 to S-9) and waters to the east and south of Viet Nam (even numbered cruises S-2 to S-10). As part of the return voyage of the *Stranger* to San Diego (cruise S-11), plankton collections were obtained along a track extending from Bangkok to the south coast of Java, and from the Timor Sea northward to the east coast of the Philippines. The S-11 collections provided a framework within which the more intensive local studies off Thailand and Viet Nam could be placed in broader biogeographical perspective.

Accounts of the cruises, together with lists of the station positions, the observations made, and the processed hydrographic data are provided in Volume 1 of the Naga Reports (Faughn, 1974). Physical oceanography of Southeast Asian seas based on pre-Naga data is described by Wyrtki (1961) and that of the Gulf of Thailand based on Naga data by Robinson (1974).

The euphausiids are among the largest organisms that may still be regarded as zooplankton. From the standpoint of food chain interactions in the Gulf of Thailand and the South China Sea, euphausiids are omnivores, though larvae and immature stages of these shrimp-like animals are believed to be primarily phytoplankton consumers.

Adult euphausiids, which commonly attain a body length of 8-15 mm, utilize both phytoplankton and small zooplankton (Lasker, 1966; Weigmann, 1970; Roger, 1973a). Food is accumulated both by the filtering action of the trunk appendages and by selective grasping. Detrital material probably provides additional food for such abundant and widespread species as *Pseudeuphausia latifrons*, a predominant Indo-West Pacific coastal species which lives throughout the area of the Naga investigation. During daylight hours, adult *P. latifrons* lives on or near the sea floor in the shallow shelf waters (Wickstead, 1961). a place suitable for a facultative detritus feeder.

Euphausiids may therefore constitute broad connecting links in the food web, having feeding habits that overlap those of both the primary consumers (small zooplankton) and the plankton-grazing fishes such as the mackerel *Rastrelliger* (Matsui, 1970). In turn, they serve as prime food for bottom fishes in the shallow seas and for predaceous mid-depth fishes of the open seas (Roger, 1973b).

Euphausiid populations may become particularly vulnerable to predation when they aggregate or stratify. Daytime swarming of adults in coastal waters can be associated with breeding or spawning cycles (e.g. Mauchline, 1960), or a consequence of abrupt mixing of water masses (Komaki, 1967). Stratification of euphausiids at particular depths is maintained by means of diurnal responses of these organisms to light intensity (e.g. Boden and Kampa, 1967). Certain

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euphausiids are stratified near the sea surface by night (Brinton, 1967), apparently feeding upon the mircoplankton of the euphotic zone. During the daytime many of the same species are concentrated well below the thermocline, at levels which depend upon the response of the particular species to the amount of light, and also to physical characteristics of the water column and depth of water (in neritic areas). At these depths the euphausiids have access to sinking detrital and waste material, but the extent to which this is utilized as food by the oceanic species is not known. Movement between such dual habitats, known as diurnal (diel) vertical migration, is a widespread, though by no means universal, characteristic of the zooplankton (Banse, 1964). Most of the taxonomic categories of planktonic invertebrate animals include some species that move toward surface waters at night and descend to levels of low illumination during the day. Roger (1973c) and Youngbluth (1973) have pointed out the importance of these migrations in the transfer of energy from subsurface (0-400 m) to deeper layers, following McLaren (1963).

The South China Sea is the northernmost part of the complex of inter-ocean seas. Its superficial circulation changes with season and varies in extent of continuity with adjacent areas (Fig. 1a, b). It provides two distinctive euphausiid habitats: 1) the shallow shelf waters are inhabited by *Pseudeuphausia latifrons* (the offshore euphausiid species do not achieve significant concentrations in these shelf waters, intruding only a relatively short distance shoreward of the continental slope), and 2) the deep basin area of the South China Sea supports a tropical oceanic community (Fig. 1 c, d) including approximately 25 euphausiid species. Some of these are characteristic Indo-Pacific elements, e.g., *Stylocheiron diomedeae* and *E. sanzoi*. Others are panoceanic warm-water species, e.g., *Stylocheiron carinatum* and *Thysanopoda tricuspidata*. Of the epipelagic oceanic species, the latter two are the most broadly distributed in the worldwide sense and show the greatest tendency to invade the neritic environment of the Sunda Shelf. There they contribute, though relatively insignificantly, to the biomass of the coastal seas south of Viet Nam.

In addition a number of subtropical species, such as *Euphausia mutica* and *Stylocheiron suhmii*, enter the South China Sea survey area from the north, there supplementing the predominantly tropical fauna.

Descriptions of most southeast Asian euphausiid species are contained in the Siboga Report series (Hansen, 1910) and in a report on *Albatross* collections from the Philippines (Hansen, 1916). Other species found in this area are described in Hansen (1912) and in Boden et al (1955). Brief species descriptions are included in the present paper. These emphasize characteristics considered to be most useful for purposes of identification and necessary as supplements to the illustrations provided.

Maps showing the distributions of species in the Indo-Australian seas (Figs. 45-75) include, in addition to the Naga data, locality reports from Hansen (1910 and 1916) and records from the International Indian Ocean Expedition collections (Brinton and Gopalakrishnan, 1973) the *Manthine* cruises out of Singapore (Wickstead, 1961) the *Bora IV* cruise along 170° E (Roger, 1971) and the Great Barrier Reef expedition (Tattersall, 1936a). Records from the Scripps Institution collections, plotted also in Brinton (1962a), are from the following expeditions: Troll, Equapac, Monsoon, Capricorn and Eurydice. These records are reproduced on the present charts, along with more recent records from Circe and Antipode expeditions. Station data for the Scripps collections may be found in Snyder and Fleminger (1965, 1972).

Maps of the world-wide ranges of the species under discussion are presented. These are intended to illustrate faunistic and climatological affinities of the species. Further, the present study focuses upon seas marginal to oceans, or connecting them, in which a species may be distributionally centered but upon which the species may or may not be distributionally dependent. Where possible the distinction will be made. The global picture of the relationship of sea and land barriers to species ranges is important to a consideration of the speciation processes, if spatial fragmentation and coalescence of populations is accepted as an essential partner to that process.

The Pacific distributions are from Brinton (1962a), and the Indian Ocean distributions are

from Brinton and Gopalakrishnan (1973). Both references incorporate the records from the literature. The Atlantic distributions, more tentative and incomplete than the others, are from a number of reports summarized by Mauchline and Fisher (1969) and from more recent work of James (1970) in the Gulf of Mexico, and Baker (1970) and Weigmann (1974) in the eastern North Atlantic. The Scripps Institution's Lusiad, Bonacca, R/V *Washington* 65-1 and Cato expeditions have provided material from the Atlantic which I have recently examined, and some midwater trawl samples from the Gulf Stream and its extension were kindly made available by the Woods Hole Institution. The localities of these unpublished records are shown in the appendix, figure 139.

The Naga plankton collections were obtained through the cooperative efforts of many Thai, Vietnamese and Scripps biologists and technicians. I wish particularly to acknowledge the program and field leadership of James L. Faughn and the direction of technical aspects of collecting by Tetsuo Matsui. Twesukdi Piyacarnchana and his students and colleagues at Chulalongkorn University, and also staff members of Kasetsart University, contributed much to the processing and examination of plankton samples. Charé Watanaprida made a study of *Pseudeuphausia latifrons* based upon many of the Naga samples from the Gulf of Thailand; his independent observations were submitted in a report to the Faculty of Science, Chulalongkorn University.

The stippled illustrations of the euphausiid species are the work of Susan Ahrend Congleton. Annie Townsend assisted in the preparation of the data and the manuscript. Margaret Knight and William Newman critically read the manuscript and made valuable suggestions.

METHODS AND MATERIAL

Two types of nets were used to obtain the samples examined in the present analysis, a 2-m mouth diameter (1.0 mm mesh width) stramin ring net, and a 1-m mouth diameter (0.6 mm mesh width) ring net. These nets and the towing procedures are described in Naga Reports, vol. 1 (Faughn, 1974). The methods may be summarized as follows: (1) the 2-m stramin net was towed nightly as a surface or near-surface collector of micronekton. In addition, 4 to 6 collections were made to depths of about 400 m over the South China Sea basin during each even-numbered cruise (S-2 to S-10). (2) Net tows using the 1-m net were made in conjunction with all hydrographic casts. The net was towed obliquely with the vessel moving at 1.5-2 knots. The towing wire was paid out at 40 m/min until the net was near the sea floor (in neritic waters), or until 200 m of wire was out (in oceanic waters). It was then retrieved at 20 m/min, or more slowly when a relatively short towing line was used because of the shallowness of the water.

The ship's speed was regulated so that the angle of the towing wire was maintained as nearly as possible at 45°. The hauling time varied between 10 and 30 minutes so that each sample contained elements of plankton populations integrated across horizontal distances of 0.5 to 1.5 km. A 100-lb. weight was suspended from the wire below the point of attachment of the net bridle. The maximum depth attained by the net was estimated from the angle of the wire, assuming a straight wire to the net. With 100 m of wire out, the depth-of-tow calculated by this method was shown to differ by no more than about 2 m from the true depth recorded of a film made by a pressure bellows (Ahlstrom, 1948).

A TSK flowmeter was mounted in the mouth of the net to provide an estimate of the volume of water filtered. Meters were calibrated for the relationship between the number of revolutions of the impeller and the distance towed. The volume of water strained by the net was assumed to be approximately equal to that of a column of water having a cross-section equal to the area of the mouth of the net (0.785 m^2). Counts of euphausiids were standardized on the
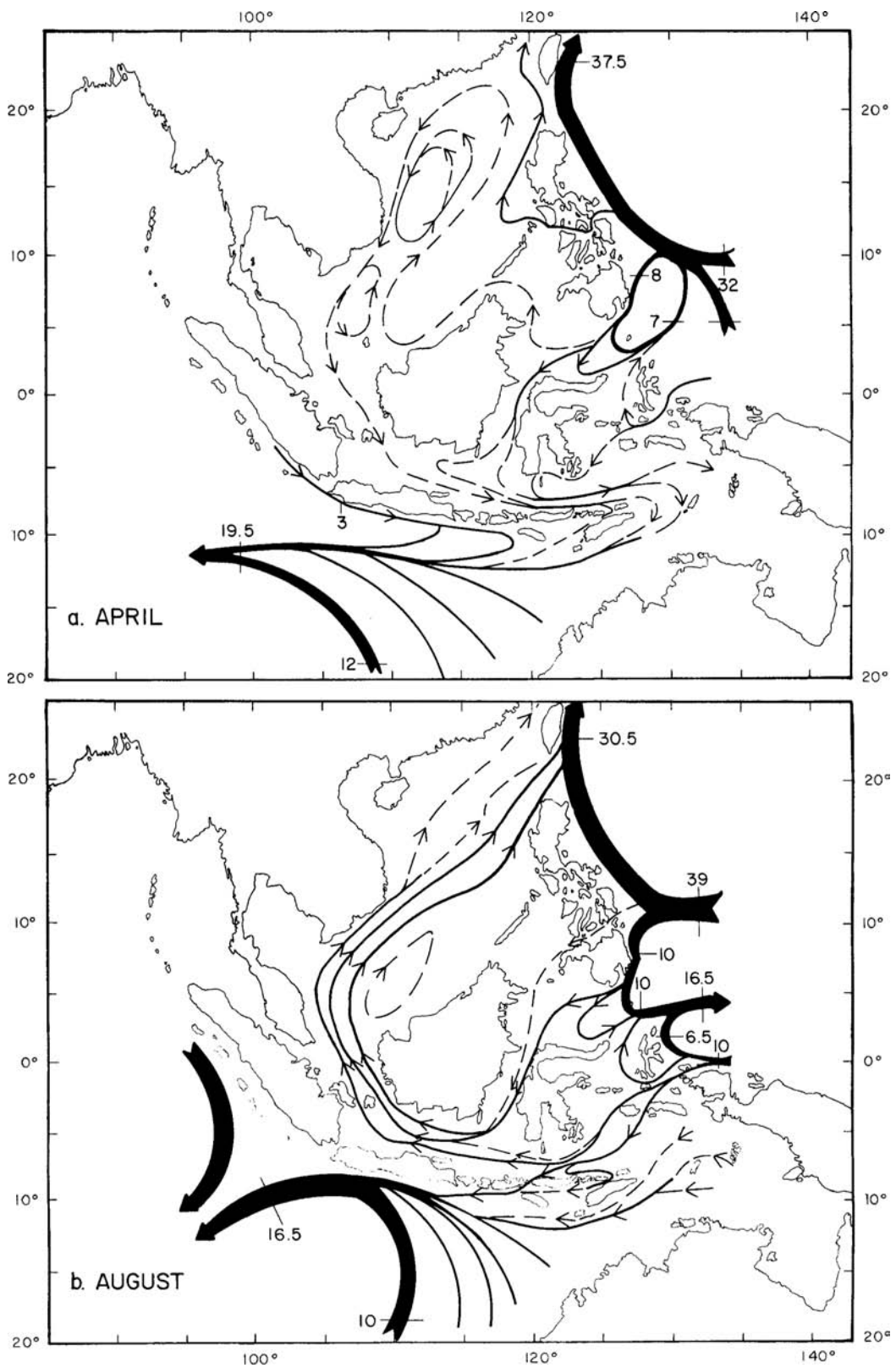
Figure 1 a, b. Transport of surface circulation in million m^3/sec. a) April, b) August, after Wyrtki (1961).
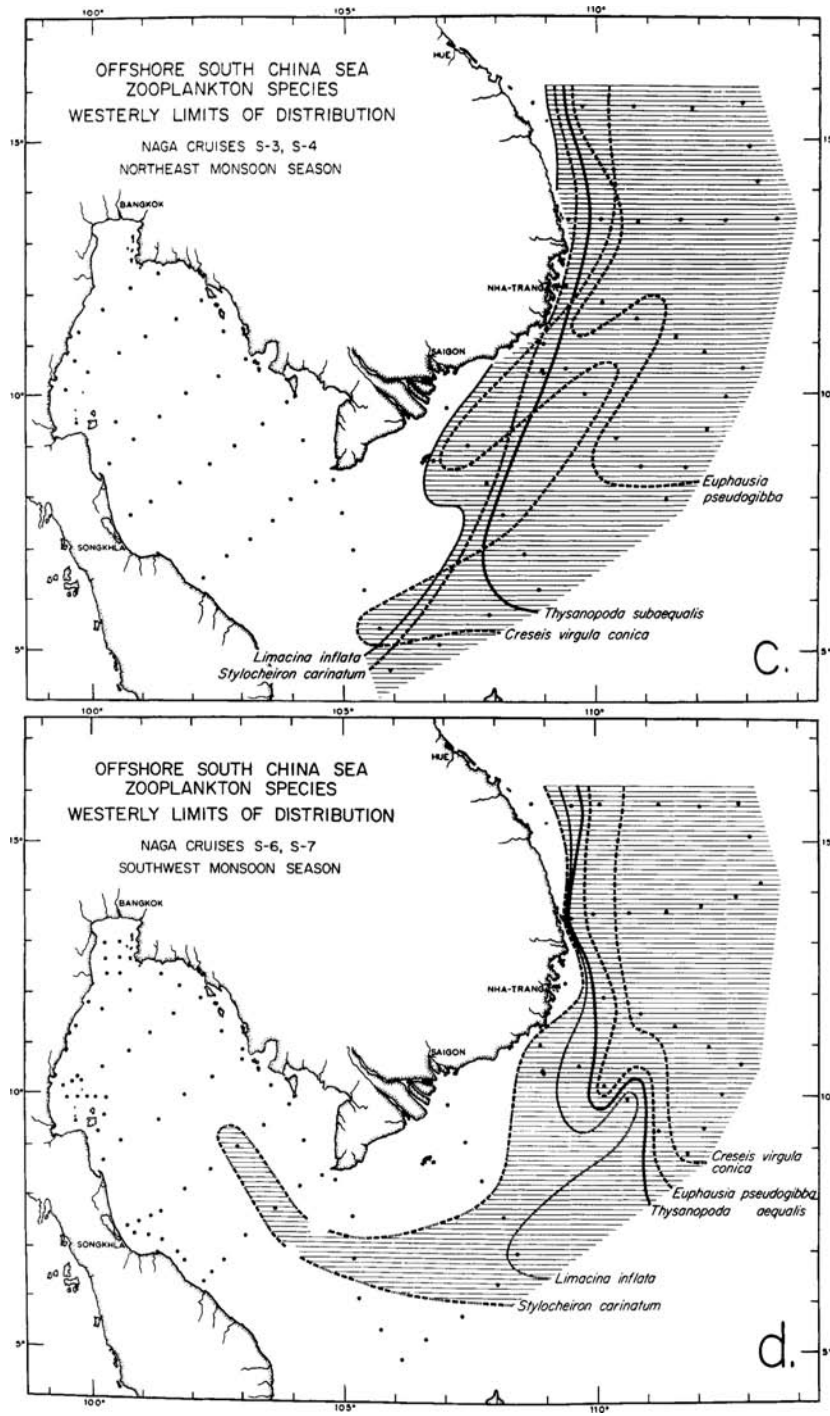
Figure 1 c, d. Range limits of offshore plankton species c) February-March, d) June-August. Pteropod distributions, *Creseis* and *Limacina*, from Rottman (1975).

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basis of 1000 m^3 of strained water.

In the laboratory treatment of the plankton samples it was usually necessary to use aliquots. The procedure, which is the same as that described in Brinton (1962a), included (1) counting and measuring all specimens in an aliquot of the sample, and (2) scanning the remainder of the sample under the microscope for species that appeared not to have been representatively aliquoted, or that were entirely lacking in the aliquot. In general, the fraction served for counts of the dominant species, and the whole sample for the rarer species.

When the sample was seen to contain few euphausiids, an aliquot of 1/4th or 1/5th of the sample was taken. 1/10th was usually counted when the sample was rich, that is, when it appeared to the naked eye to contain 1000 or more euphausiids. The method used for aliquoting required that the sample first be agitated. When the plankton was in suspension it was poured into a 500-ml, graduated cylinder. The combined volume of plankton and fluid, usually adjusted to about 400 ml, was measured and all but the intended aliquot (approximately the lower 1/10th or 1/5th) was quickly poured back into the original container. Since the larger euphausiids would otherwise have settled to the bottom of the cylinder in 20-40 sec, the material was kept in a state of agitation during the fractioning, except when the volumetric reading was made. Most of the euphausiid specimens in the samples were larvae or immature individuals. These remained longer in suspension than the adults.

The reliability of the aliquoting and counting procedure and such variable factors as depth-of-tow and time-of-day-of-sampling were examined (Brinton, 1962a). Replicate counts indicated that aliquots obtained by this method were random fractions of the samples.

The importance of scanning the entire sample for the rarer species was indicated by the fact that in random aliquots, a species with a mean density of 1 individual per aliquot would be absent in about 37% of all the aliquots, and a species with a mean concentration of 0.5 individuals per aliquot would be absent in about 61% of all the aliquots.

In estimating and plotting abundance of euphausiids in the Gulf of Thailand and South China Sea, no station-to-station correction has been made for differences between observed day and night abundances. Stations were randomly sampled with respect to time of day, and the mean densities are therefore considered comparable among cruises, regions and species. In general, larvae were equally sampled, day and night, while adults were two to three times more abundant in nighttime samples.

SECTION I. SEASONAL DISTRIBUTION OF PLANKTON BIOMASS AND EUPHAUSIIDS

GULF OF THAILAND PLANKTON BIOMASS

Two regions, the Gulf of Thailand and the western South China Sea, were investigated in alternate months, and will be considered separately. The Gulf is the more southern of two westerly arms of the South China Sea, the other being the Gulf of Tonkin. It is shallow, with a central depression 75 m deep and with a sill depth of 67 m at its confluence with the Sunda Shelf to the southeast.

Flow into the Gulf past Cape Camau at the southern tip of Viet Nam is year-round according to the interpretation of the Naga data by Robinson (1974). During October-January this flow introduces South China Sea water diluted by the peak of the Mekong outflow. Just inside the Gulf, this mixes with more coastal water, partly derived from the same Mekong watershed, through drainage directly into the Gulf along its southeast edge from streams and canals. It will be seen that this frontal region encompassing and seaward of the Phu Quoc Island-Cape Camau Bight (9°N, 104°E) sustains a large plankton crop, even during April when surface water entering the Gulf reverts to high salinity (34 ‰) as runoff is diminished.

Surface flow out of the Gulf is generally on the western side along the Malay peninsula.

This flow appears not to be continuous, sometimes subsiding or shifting eastward toward the middle of the mouth of the Gulf.

The Gulf's surface circulation, particularly in the northern half, is basically cyclonic during November-May and anti-cyclonic during August-October. Surface circulation off the mouth, southwest of Cape Camau, is consistently cyclonic: northerly in the east, then westerly (near 9°N), and turning southerly in the west. This provides the populations and physical processes of the inner Gulf with a degree of autonomy, apart from the sea to the south. In addition, the internal circulation appears sometimes to be sufficiently sluggish to allow some characteristics (e.g., high salinity cells) to persist in parts of the Gulf from cruise to cruise, after the causative factor has gone.

Of the environmental parameters available for correlation or comparison with the distribution of plankton and of individual species or life stages, temperature and salinity provide the most extensive data. Where not directly affecting organisms, temperature and salinity may be significant as measures of hydrographic processes considered to be of importance to the production and development of populations, particularly in neritic or coastal regions. These processes include upwelling vs. sinking, vertical mixing vs. stabilization (stratification), and dilution from rivers vs. incursions of relatively saline deep water or oceanic surface water. General correlations of abundances with specific temperature and salinity conditions are evident cruise-by-cruise but not for the annual picture as a whole. No attempt is made here to determine values that are limiting or causative biologically.

Other parameters to be discussed in relation to the species distributions are the direction of currents and the amount of plankton biomass. Oxygen concentration appears unlikely to influence plankton distribution in this generally well ventilated system (Robinson, 1974) and will be referred to in few instances.

The abundance of zooplankton in the Gulf of Thailand will be discussed in relation to the coastal regions. These are the places of highest plankton production, directly influenced by the seasonal reversal of the monsoon winds, by tidal mixture and by land drainage. They are the regions in which fishing activities are concentrated. The shallow northern part of the Gulf, in which lie the stations occupied north of Koh Chang in the eastern Gulf (12° 15′N) and Koh Rad in the western Gulf (11° 45′N), is called area A (Fig. 2). Here the range of depth is 20-40 m.

Coastal waters of the western part of the Gulf, to a distance of about 70 miles from the shore of Thailand, comprise area B.

Area C lies along the eastern margin of the Gulf. It encompasses coastal waters of southeastern Thailand, Cambodia and southwestern Viet Nam.

Salient features of the temperature and salinity regimes are summarized in figure 3 a-h, based on the hydrographic data in Faughn (1974) and Robinson (1974). Isopleths delineating surface salinity are given on the charts of distribution of *Pseudeuphausia latifrons* (Figs. 9, 10); adjoining charts show surface temperature and upper level flow as described in Robinson.

From October to January (S1-S3) the surface waters are cool and progressively cooling (Fig. 3a). The western side (area B) becomes the cooler side. In October, all areas except mid-Gulf (Fig. 9) are at or near maximum dilution from runoff (Fig. 3e). The western side remains so through January, while the eastern side (area C) increases in surface salinity during October to January (Fig. 3 e, h), the season of dry northeast winds. Mixing of the water column is evident from the minimal temperature stratification (Fig. 3c), though salinity stratification persists (Fig. 3g), evidently owing to continuing runoff. Between January and May (S3-S5) annual warming takes place throughout the Gulf and surface temperature exceeds 29.5°C everywhere, for the only time in the year. Surface salinities generally increase or remain static as the dry season continues. In the upper Gulf (area A, Fig. 3e, f) Chao Phya River runoff evidently underides warm surface waters. The Gulf approaches a stabilized state, with thermal stratification at a maximum (Fig. 3c) and salinity stratification at a minimum (Fig. 3g).

The southwest monsoon develops during May to August (S5-S7), bringing rain and diminished radiation. However, reduced surface salinity is evident, as yet, only in the eastern Gulf
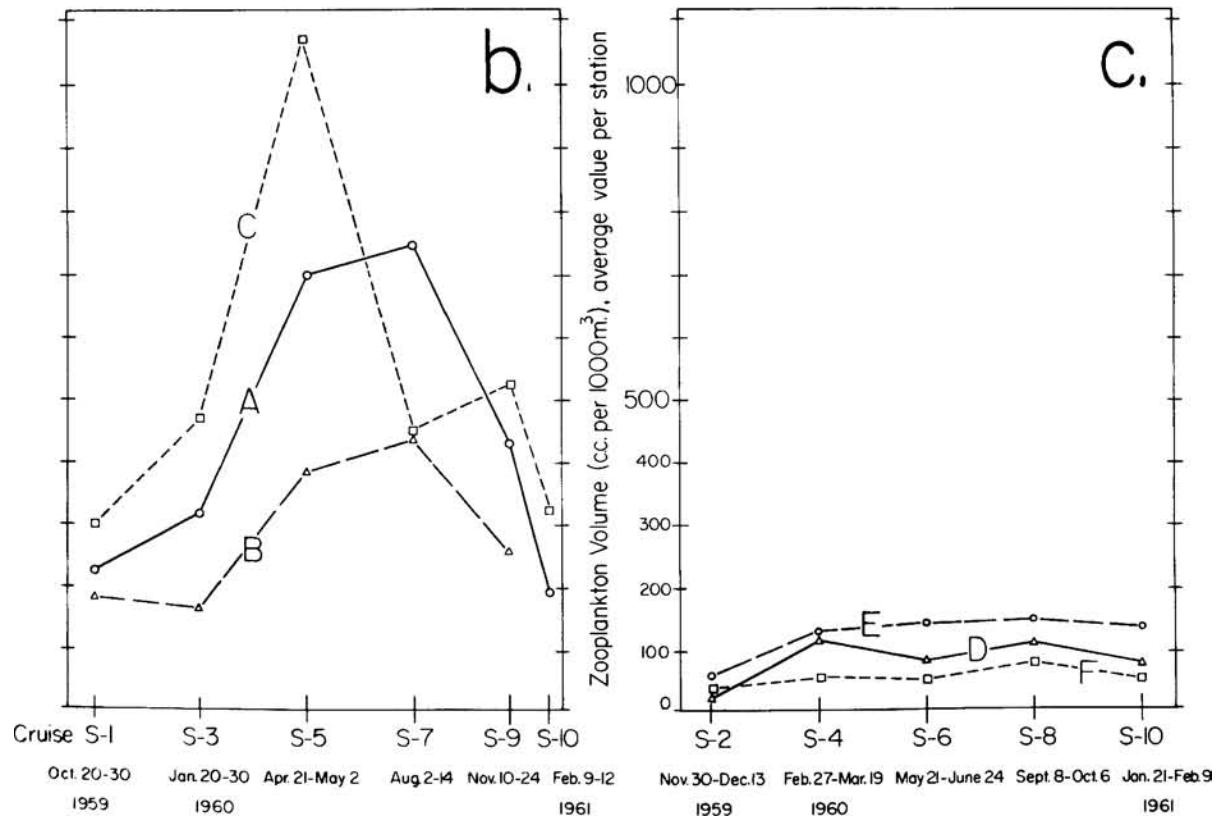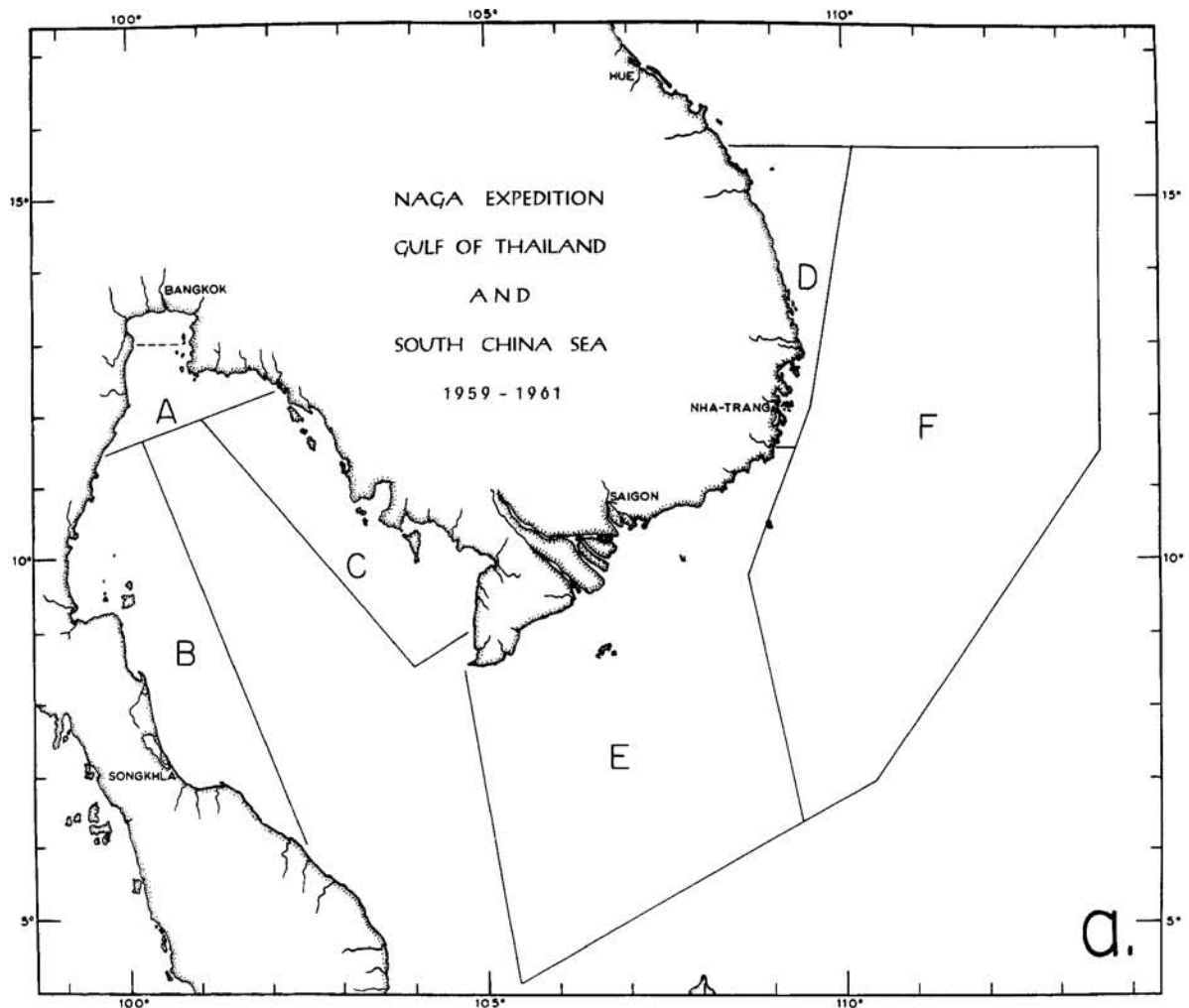
Figure 2. a) Areas of Gulf of Thailand and South China Sea designated A-F. b) Plankton biomass by area and cruise, Gulf of Thailand. c) South China Sea.
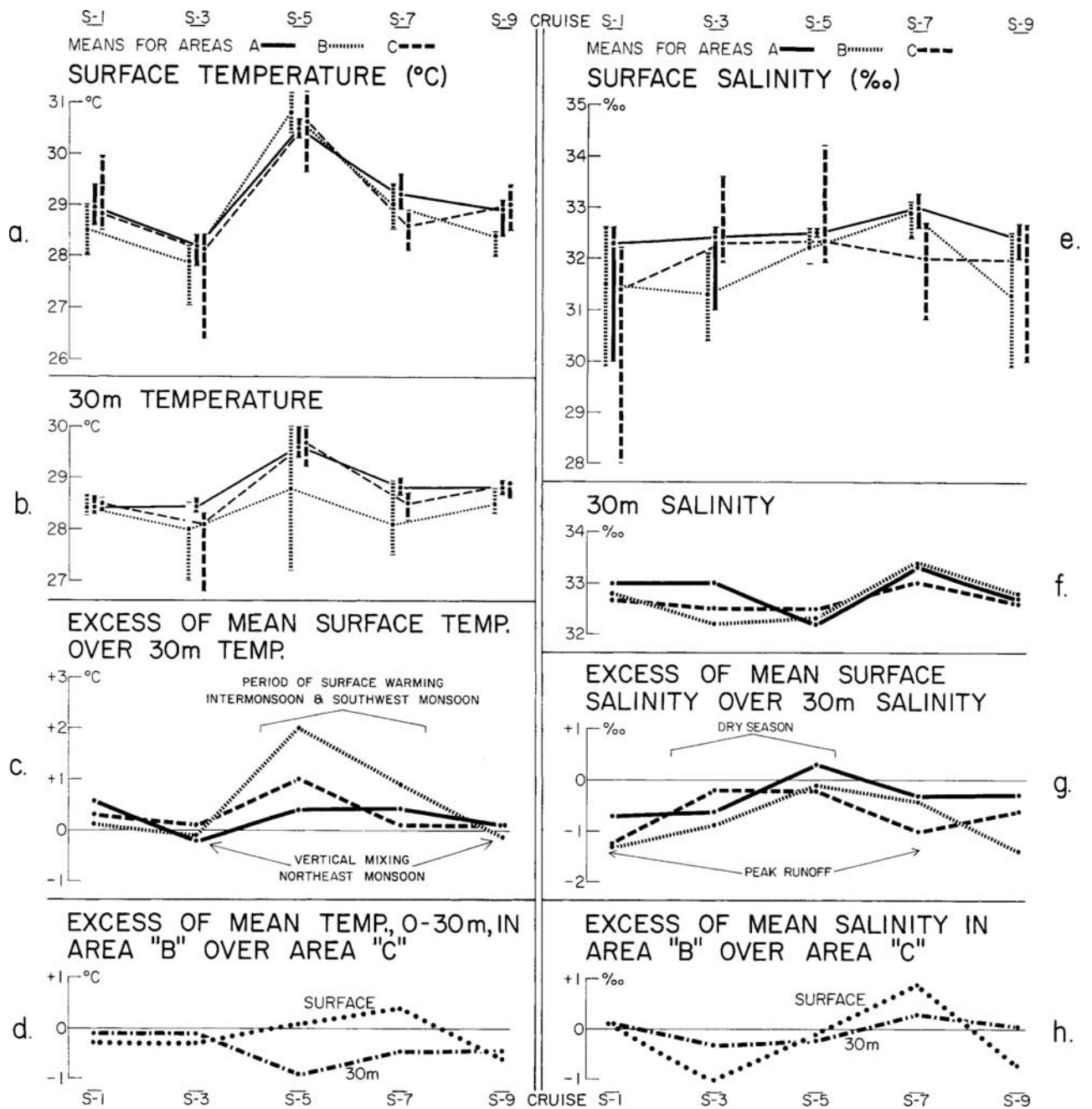
Figure 3. Temperature and salinity characteristics at the surface and 30 m depth, Gulf of Thailand areas A-C. Vertical bars show ranges of values.

(area C, Fig. 3e, h) because, in the west and north, surface water is blown away from shore and is replaced by high salinity water of deeper origin. Surface waters of the western Gulf, though now cooler than during April-May, are warmer than those to the east, while deeper water in the west remains cooler than in the east.

Between August and November (S7-S9) the southwest monsoon subsides and the northeast winds are first felt. Temperature stratification, diminished during the southwest monsoon, breaks down completely (Fig. 3c) with intensification of the northeast winds. Offshore winds in the eastern Gulf have not yet brought about a reduction in temperature there, and this side remains warmer than the western Gulf (Fig. 3d). Dilution by fresh water, though Gulf-wide since August, is most intense in the west (Fig. 3e, h) in November.

Thus the Gulf of Thailand, with its variable salinity, has some characteristics of an estuary. These are weakly developed, doubtless because of the Gulf's large size (500 km long and at least 320 km wide). The water mass is generally two-layered with respect to salinity though the degree of stratification varies strongly with season. The upper 40-50 m is supplied with rain and runoff during and immediately after the southwest monsoon season. Conspicuous dilution is evident only in extremely marginal areas, and the upper layer has a salinity that varies only within the range of 30-33 ‰. The deeper layer below 40 m depth flows into the Gulf across the sill, constantly bringing water of higher salinity, 33-33.5 ‰.

Mixing of the two layers at the interface is continuous, but this process is most active at the height of the monsoons, July-September and December-February. This, together with tidal mixing, the admixture of nutrients through runoff, and renewal of nutrients by coastal upwelling, brings about a high level of fertility in the Gulf. As will be noted, the zooplankton standing crop is commonly of the order of 200-1000 cc (wet displacement volume) for 1000 m^3 of water, which compares with an annual mean of 350-450 cc for the productive northern part of the California Current (Thrailkill, 1956), an area long sampled by means of the same collecting gear used during Naga.

Values for production of carbon in the region commonly exceed 1.0 g per m^2 per day (Steeman-Nielsen and Jensen, 1957). Nevertheless, the water appears to be well oxygenated at all depths (Robinson, 1974). In rare instances values of <2.5 ml O^2 per liter were observed, and these were in near-bottom waters.

With respect to its planktonic fauna, the Gulf must also be regarded as more neritic than estuarine. *Pseudeuphausia latifrons*, the characteristic Indo-Pacific tropical neritic euphausiid, lives and reproduces throughout the Gulf, except in places of particularly high dilution. Of the 45 observed species of calanoid copepods, the proportion regarded as neritic varied only between 64% and 71% from cruise to cruise, while the oceanic species were 19-23% and those considered estuarine, 8-18% (Fleminger, 1963).

Thus the composition of the biota is complex at all times. For a particular geographical area, the proportion of the biomass made up by one species is almost always small. For the whole of the Gulf, the part of the biomass made up by *Pseudeuphausia* varied between 0.05% (August 1960, Cruise S-7) and 1.5% (January 1960, Cruise S-3) (Table 2). Certain samples, nevertheless were found to be dominated either by this species, by a particular chaetognath, copepod, or sergestid decapod, or sometimes by meroplankton forms, notably an ophiuroid (Echinodermata) larva or a caridean (Decapoda) larva.

Estimates of zooplankton density were obtained for each survey cruise for the Gulf of Thailand areas A, B and C (Fig. 2). Mean values for each area were determined by averaging standardized displacement volumes of all samples from an area. The individual values are listed in volume 1 of the Naga Reports (Faughn, 1974). The geographical distribution of plankton biomass during each of the Naga cruises is shown in figures 4-6.

Sampled volumes were standardized as if 1000 m^3 of water were strained by the net. Organisms larger than about 15 mm in length, such as large salps, jellies, and post-larval fishes, were not included in these estimates.

October 20-30, 1959 (Cruise S-1). During October (1959) mean plankton volumes for all Gulf of Thailand areas were uniformly low. Area C, the eastern side of the Gulf, was richest (303 cc per 1000 m^3 of water) and area B on the western side was poorest (171 cc per 1000 m^3). Area A, to the north, was intermediate (225 cc per 1000 m^3). During this inter-monsoon period the opposite sides of the Gulf were similar with respect to both temperature and salinity (Fig. 3d). Surface temperatures throughout the Gulf (28-30°C) were as much as 0.3°C warmer at the surface than at 30 m (Fig. 3c), while salinities (>30 ‰ at all but two stations) averaged approximately 1.3 ‰ lower at the surface than at 30 m depth, evidently a consequence of the June-September rains (Fig. 3g). Thus, while plankton densities were low, with some tendency toward concentration in coastal waters (Fig. 4a), the Gulf water mass was in a nearly uniform state, with moderate stratification. Lowest plankton volumes for October were found in (1) mid-Gulf, (2) a low-salinity area north of Koh Pennang (10°N, 100°E), and (3) the warmest (29-30°C at surface) part of the Gulf, to the northeast.

January 20-30, 1960 (Cruise S-3). With the development in December-January of the northeast monsoon season, mean volumes increased to 317 cc in the upper Gulf (area A) and to 470 cc in the eastern Gulf (area C) (Figs. 2b, 4b). In area B, where piling up of water and downwelling would be expected during this season, volumes were scarcely lower than those of the October survey (153 cc as compared with 171 cc). In contrast to October, salinities were high (32-33 ‰) along the consistently rich southwestern coast of Viet Nam (southern part of area C, Figs. 3e, 9). General freshening of the surface layer, now most evident in the northwestern Gulf where salinities were as low as 30.4 ‰, was not associated with an increase in the amount of the general plankton community.

April 21-May 2, 1960 (Cruise S-5). Zooplankton measured during the late-April inter-monsoon period averaged more than twice that of the previous survey (S-3) in each Gulf area (Figs. 2b, 5a). Surface temperatures were high (above 30°C) throughout the Gulf. Winds were southerly, but weak in the south, increasing in intensity as the *Stranger* worked northward. Runoff was at a minimum during this terminal part of the dry season. The development of stability, following the mixing brought about by the northeast monsoon, was associated with a maximum zooplankton crop on the eastern side of the Gulf and increased volumes elsewhere.

A feature in April was a broadening toward the southwest of the area of high zooplankton concentration always found along the eastern side of the Gulf (Fig. 5a). High volumes extended from the Phu Quoc Island and Pulo Panjang regions to mid-Gulf, along the path of circulation which followed a strongly stratified band, nearly uniform with respect to high surface temperature and somewhat low surface salinity (31.7 ‰-31.9 ‰) (Fig. 9).

Other high zooplankton concentrations observed during April-May were in the area of the Pannan and Samuie Islands to the west, and in the upper Gulf, in area A.

August 1-24, 1960 (Cruise S-7). With the development of the southwest monsoon, mean volumes continued to increase along the western side of the Gulf (area B) to 433 cc and in the upper Gulf (area A) to 741 cc, the annual maxima (Figs. 2b, 5b). On the eastern side (area C), surface salinity was low with the initiation of runoff (Fig. 3e), and zooplankton was diminished to a mean of 402 cc, as compared with a value of more than twice that for the preceding inter-monsoon period.

Surface temperatures had now fallen within the range of 28.0-29.5°C, indicating a reduction in vertical stability of the water mass. Upward displacement of bottom water was most evident in the area of Koh Pennan and Koh Samuie to the west. There the plankton was richer than offshore. In this island area, temperature at a depth of 30 m was 27.5-28°C, compared with 28-29°C over the rest of the Gulf.

The northerly course of the coastal circulation in the upper half of the Gulf would be expected to carry enriched water northward from the Koh Pennan center at this season. Highest
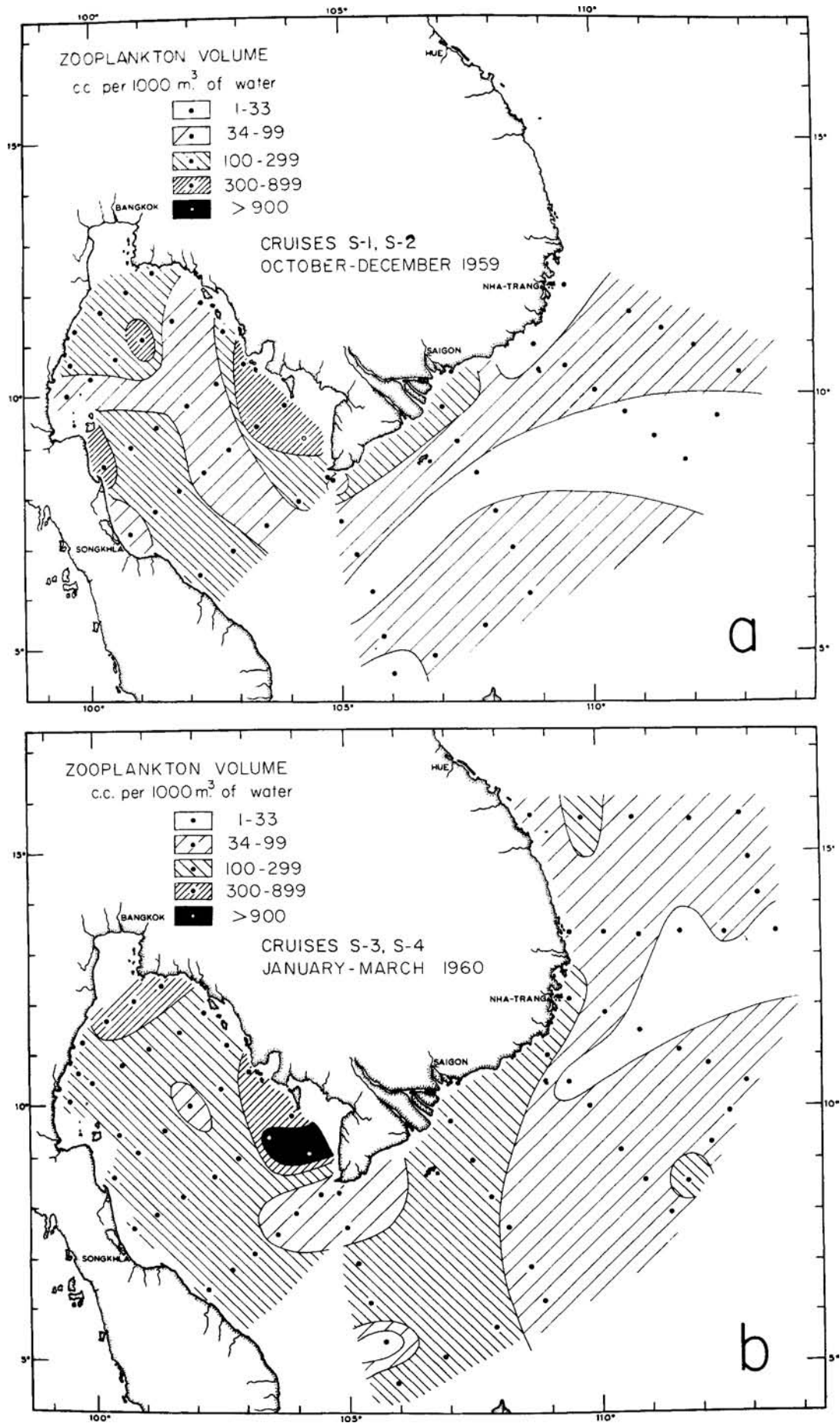
Figure 4. Zooplankton displacement volume, a) October-December, 1959. b) January-March, 1960.
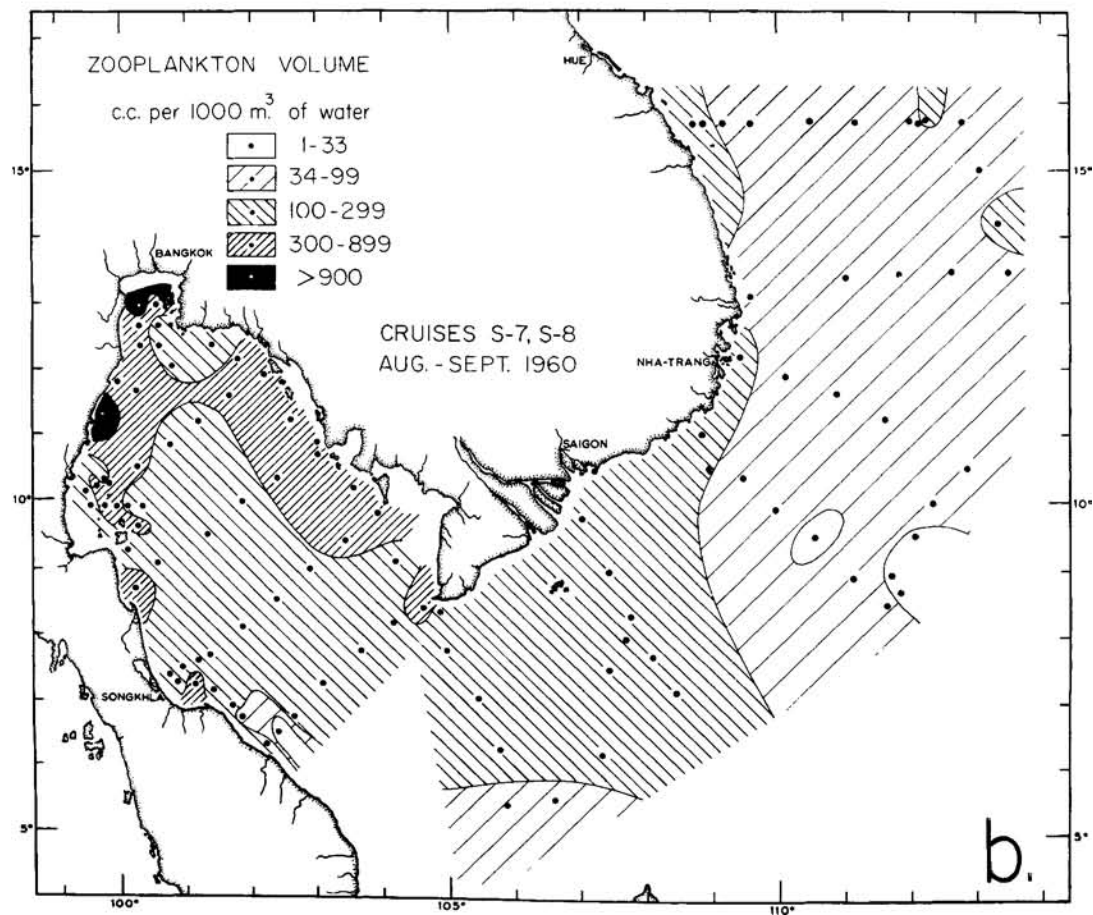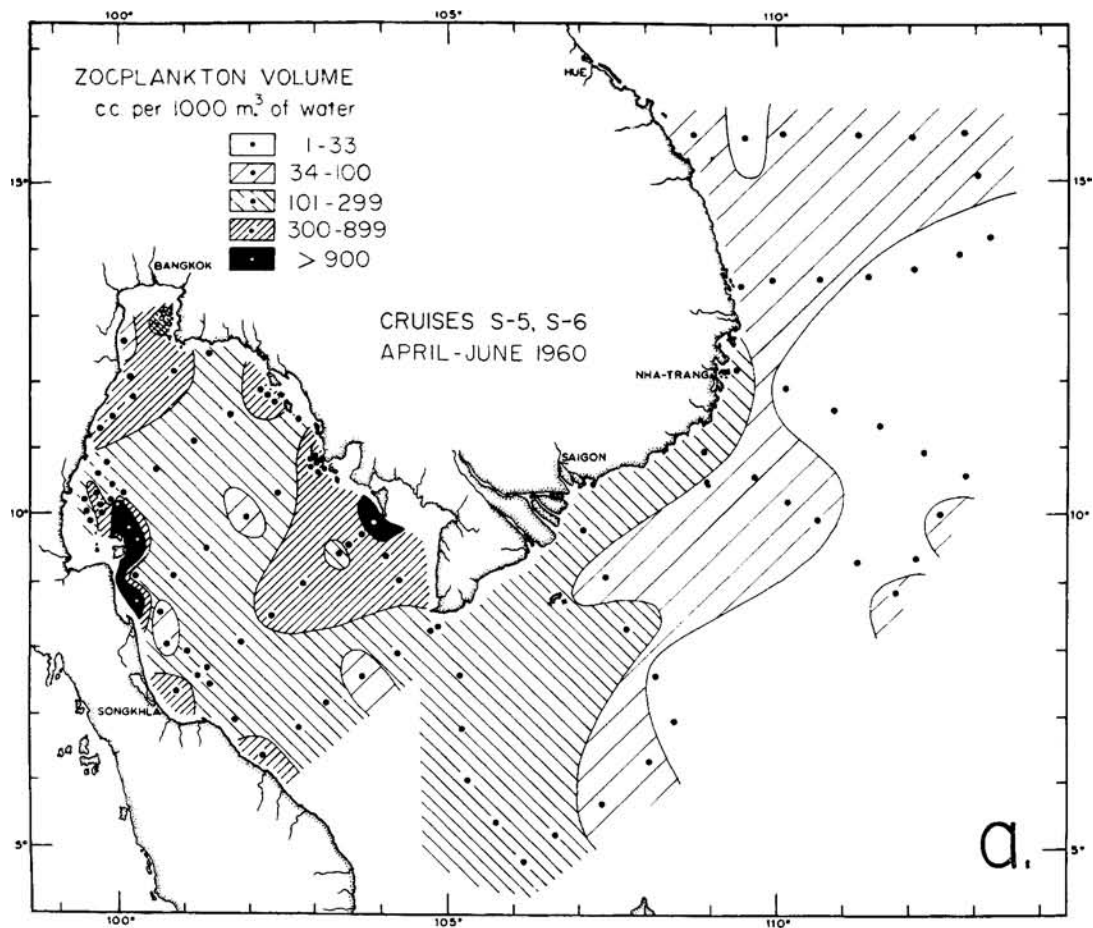
Figure 5. Zooplankton displacement volume, a) April-June, b) August-September, 1960.
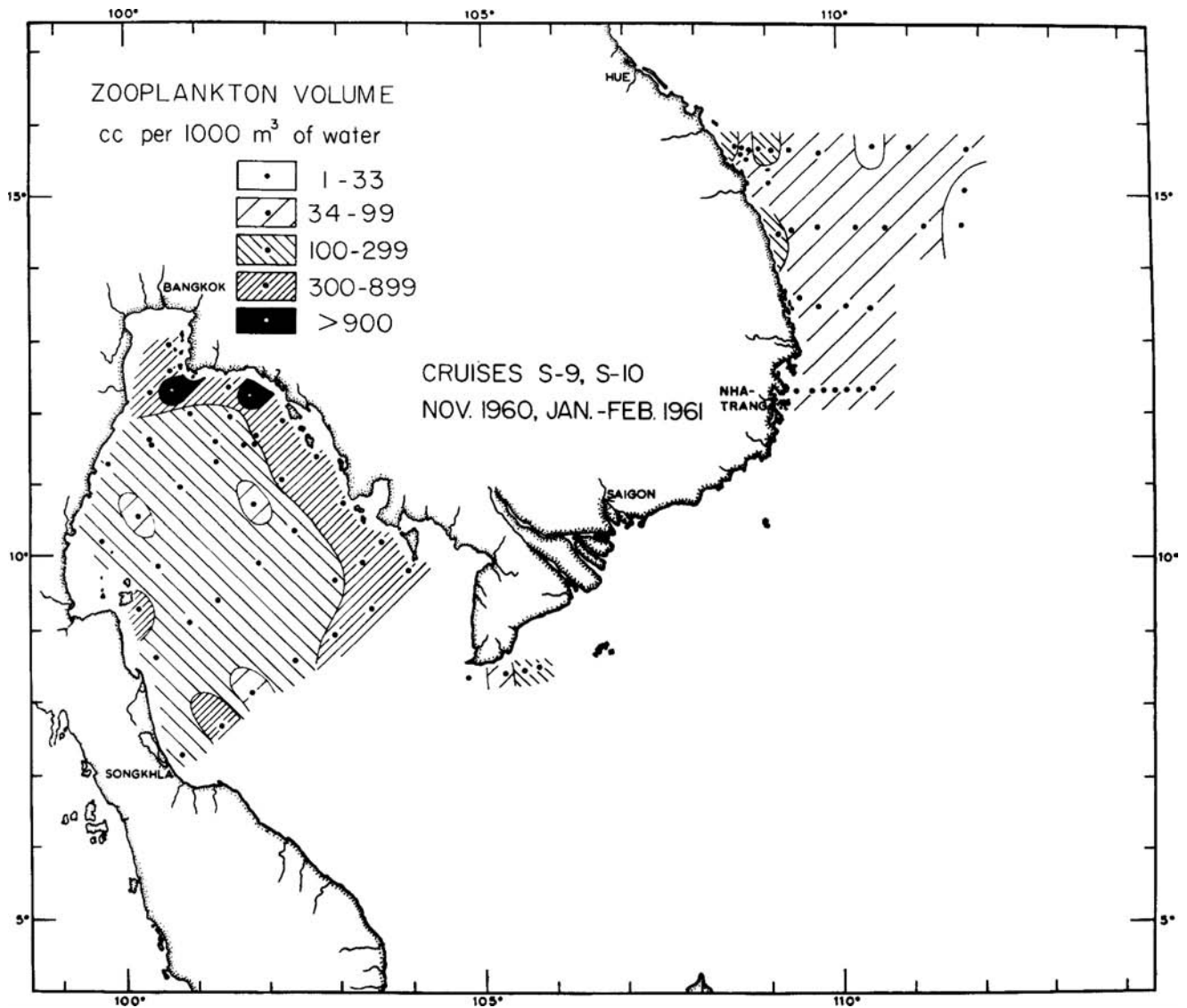
Figure 6. Zooplankton displacement volume November, 1960, (Gulf of Thailand), January-February, 1961 (South
China Sea).

plankton densities were found to the north, along the Chumporn-to-Prachuap coast of Thailand, 10-12°N (Fig.
5b).

November 10-14, 1960 (Cruise S-9). This is early in the rainless season. The northeast winds off the eastern
land mass are not yet well developed, but it is the period when residual runoff peaks on both sides of the Gulf.
Plankton concentrations (Fig. 6) were highest in the eastern Gulf (area C), showing an increase to a mean of
524 cc per 1000 m^3 over 402 cc for cruise S-7 (Fig. 2b). Samples from the western Gulf (area B) contained
less plankton than during the summer season, and this area remained half as rich as area A.

February 9-12, 1961 (Cruise S-10). Returning from the South China Sea in February, 1961 the *Stranger*
collected 25 plankton samples along the eastern side of the Gulf (area C), and four in the upper Gulf (area
A). These were not strictly comparable geographically with the samples from previous Gulf cruises. However,
they indicated a 40-50% decline in the amount of plankton from November to the time of the February cruise,
from the waxing of the northeast monsoon to its waning (Fig. 2b).

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A comparison may also be drawn between the S-10 and the S-3 values, a year apart. A mean volume of 186 cc was obtained from the upper Gulf (area A) in February 1961, similar to the 317 cc for the same period a year earlier (S-3). Also, the mean of 320 cc for area C in February 1961 differs little from that of 470 cc for January 1960.

In summary, the easternmost waters of the Gulf sustained the highest biomass during the inter-monsoon season, April-May The western and northern parts of the Gulf were richest under the influence of the southwest monsoon. Highest biomass was consistently associated with the margins of the Gulf. The northeast monsoon season, October-February, was the time of lowest crop.

SOUTH CHINA SEA PLANKTON BIOMASS

Seasonal aspects of the distribution of euphausiids and of zooplankton biomass in the South China Sea to the east and south of Viet Nam are considered in relation to three geographical areas (Fig. 2a). D is the northern shelf area, narrow off Nhatrang Bay but broadening northward to 17°N at the mouth of the Gulf of Tonkin. E is on the extensive Sunda Shelf to the south, contiguous with the Gulf of Thailand. F is the deep oceanic basin of the South China Sea, bounded at its eastern edge by a submarine plain from which arise numerous atolls and reefs.

Plankton volumes in the South China Sea consistently averaged less than 150 cc per 1000 cubic meters of water, as compared with the range of 200-700 cc found for the Gulf of Thailand (Fig. 2b, c). Area E in the south was at all times richer than the narrow northern shelf, area D. The deep offshore South China Sea basin, area F, was generally poorest.

November-December, 1959 (Cruise S-2) (Figs. 4a, 7e). Just as the plankton sampled during the October, 1959, Gulf cruise was low in quantity, that sampled by the first South China Sea cruise was the least found in the course of the five investigations of that region. Surface flow was southerly (Fig. 22) but weak, while thermal stratification was at a minimum. Plankton collected during this early part of the northeast monsoon season indicated concentrations generally lower than 50 cc per 1000 m^3. These extreme values, at least for areas D and F, are partly attributable to the lack of sampling to the north of 12°N on this cruise.

February-March, 1960 (Cruise S-4) (Figs. 4b, 7e). Plankton volumes were higher than during S-2 throughout the area, conspicuously along the coast and in the southern shelf waters. They reached their peak for the year in area D when it was the coldest part of the South China Sea survey region, i.e., during the period of continuing northeast winds and strong southward flow of coastal water. Temperatures also were low in the offshore area F as volumes increased somewhat. The southern shelf waters (area E), though cooler at 30 m of depth than during the previous cruise, were now warmer at the surface, and thermal stratification and a much increased plankton crop were evident.

May-June, 1960 (Cruise S-6) (Figs. 5a, 7e). The onset of the southwest monsoon season was observed during this cruise. A trend toward northerly flow of water across the area was accompanied by increased temperatures in the surface layers, stability in the biomass in the southern and offshore areas, E and F, and reduced biomass in the northern area D.

September, 1960 (Cruise S-8) (Figs. 5b, 7e). Increased biomass was observed in all areas. Along the northern coast (area D) strong thermal stratification of the water column was associated with peak dilution, apparently from the north. There the biomass increase was like that following the northeast monsoon season (S-4). Offshore (area F), salinities were still high, but the vertical temperature gradient was strong, associated with a shallow thermocline. This, in conjunction with generally offshore flow, brought about conditions for the annual biomass maximum.

Over the Sunda Shelf to the south (area E) temperature above 30 m was at the annual

peak (though it was lower at the surface than in waters to the north, apparently owing to the thorough mixing of the shelf water during the southwest monsoon season just concluded). Salinities were much reduced as a consequence of land drainage. Currents were still northerly, bringing shelf water from the southwest. These features were concurrent with the biomass maximum over the shelf.

January-February, 1961 (Cruise S-10) (Figs. 6, 7e). The northern areas D and F were investigated at the height of the northeast monsoon. Area E was represented by only three samples collected west of the Condores Islands, 9°N. As was noted during the cruise carried out late in the northeast monsoon season in 1960 (S-4), water temperatures were low throughout the region. Plankton volumes in areas E and F were comparable for the two cruises, S-4 and S-10, averaging near 135 cc for area E and 50 cc for area F. Area D, however, was somewhat poorer in January-February, 1961, than in February-March, 1960, when flow was more strongly alongshore, from the Gulf of Tonkin.

In summary, the coastal waters of the Gulf of Thailand yielded three to five times as much zooplankton as the South China Sea region, when measured as standing crop. The northern coastal waters of South Viet Nam were richest during the northeast monsoon, when there was coastal upwelling and flow from the Gulf of Tonkin. The summer season was the time of highest plankton biomass in the two other areas, the broad southern shelf and the deep offshore basin of the South China Sea (as it was in the western and northern parts of the Gulf of Thailand). This was during the period of southwest winds and mean northerly current flow in both the southern and offshore areas, when the trend of flow was from respective neritic waters to the southwest.

The South China Sea plankton was comparable in amount with volumes that have been measured in the open tropical Pacific. Though the Sunda Shelf and coastal waters of Viet Nam frequently yielded volumes in excess of 100 cc per 1000 m^3 of water, mean values for the South China Sea area of investigation extended from a low of 34 cc per 1000 m^3 for December, 1959, to a high of 68 cc for September-October, 1960. These means are in the same range as volumes recorded in the tropical mid-Pacific by King and Demond (1953), who found a range of about 15-40 cc in the North Equatorial Current and Equatorial Countercurrent, as sampled by standard 1-m net hauls, while values up to 70 and 80 cc were found in the equatorial divergence.

PSEUDEUPHAUSIA LATIFRONS, GULF OF THAILAND

Pseudeuphausia latifrons is the only euphausiid living in the Gulf of Thailand, where it occurs throughout the year. In October 1959 (Cruise S-1) its density was low and the population was made up mainly of adults (Figs. 8, 14) concentrated on the western side of the Gulf. Along this coast where flow is southerly, upwelling or offshore displacement of surface water associated with the southwest monsoon is presumed to have taken place during the preceding three months. This euphausiid tended to be scarce or lacking in the areas of low surface salinity, < 31-32 ‰ (Fig. 9).

From this western center, the Gulf population of *P. latifrons* evidently developed substantially. By January 1960 (Cruise S-3), mean numbers of larvae exceeded 500 per 1000 m^3 and juveniles exceeded 1000. These were increases of more than 30-fold over the October numbers (Fig. 8). The numbers of adults remained nearly constant. Recruitment was maximal on the side of the Gulf (eastern) directly affected by the northeast winds, while juveniles and adults were generally evenly distributed. *P. latifrons* was lacking at four stations in the western Gulf where the surface salinity was <31 ‰, and was in low density at the fifth such station (Fig. 9). As during the previous cruise, it was sparse in inflowing low-salinity water to the southeast, off Cape Camau.

Three months later, during April-May (Cruise S-5), the area of peak numbers of larvae had shifted from the east back to the west coast of the Gulf where, according to Robinson, upwelling was beginning. However, both sides remained productive (Figs. 8, 16). Immature specimens
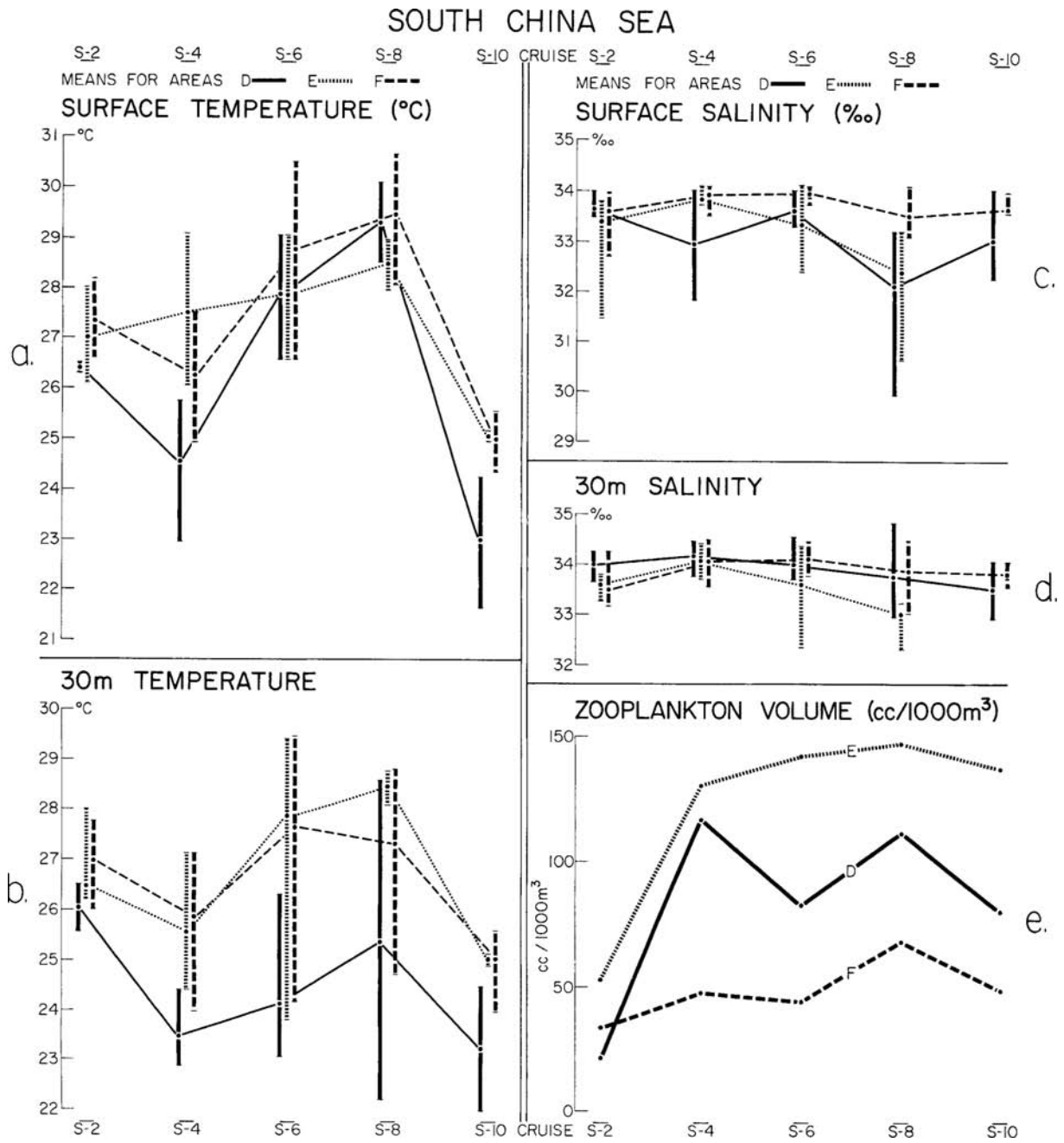
Figure 7. a-d) Temperature and salinity characteristics at the surface and 30 m depth, areas D-F (vertical bars show ranges of values), e) zooplankton biomass by area and cruise.

remained in substantial abundance, indicating survival from the January-February peak in larvae. Juveniles were evenly distributed grographically. Adults reached an annual peak which was concentrated on the east coast (area C), presumably developed from the peak stock of juveniles observed in January-February. During this relatively stable inter-monsoon period, *P. latifrons* was lacking only in the most northern part of the Gulf where surface salinity, though higher than 31.5 ‰, was lowest for the season. The area of high density of *P. latifrons*, like that of the plankton biomass, coincided with the general course of surface flow described by Robinson: southward along the northeast coast, then westward at mid-Gulf, diverging on the west coast into northerly and southerly currents.

The population appreciably declined under the influence of the southwest monsoon, as measured in August 1960 (Cruise S-7). Though evenly distributed in the Gulf, *P. latifrons* was then at the lowest mean density sampled by the expedition. Low densities on the eastern coast were again associated with the lowest salinities, and in the head of the Gulf, with the highest temperature (>29.5°C, Fig. 10). The species distribution and the hydrography were reverting, apparently, to the state observed in October (1959), with the euphausiid moving to the west, most low-salinity water in the east, and highest temperature in the north.

The only observed incursion into the Gulf of an oceanic euphausiid species took place during this cruise, S-7. *Stylocheiron carinatum* occurred in moderate and low density at two stations, at the mouth of the Gulf and just inside it (Fig. 37). These stations were evidently situated in the northwesterly current entering the Gulf, described as strong in intensity at this season (Robinson, 1974). (See discussion of *S. carinatum* in South China Sea, p. 48.)

By November (Cruise S-9) *P. latifrons* had reproduced to some extent, shown by a build-up of larvae, particularly in the northwestern part of the Gulf (Fig. 18). The north-south band of abundance (Fig. 10) fell along a zone at which northerly surface water (low in salinity and in *P. latifrons)*, having entered the Gulf on the eastern side around Point Camau, joined the cyclonic circulation of mid-Gulf which circles a cell of high salinity. *P. latifrons* remained sparse in western waters, the superficial flow of which was generally southerly, out of the Gulf.

February, 1961 (Cruise S-10) sampling along the eastern margin of the Gulf yielded extensive material from area C, late in the northeast monsoon season. *P. latifrons* was abundant along an east-west transect paralleling the Thailand coast in the northeastern Gulf with near-shore densities of up to 10 per m^3 (Fig. 11). Juveniles were predominant at all stations, while larvae were in significant numbers only to the west, south of Rayong province.

Comparable numbers were caught to the south, off Cambodia and Viet Nam (Fig. 12) where transects were made on the southerly leg (stas. U-3 to U-7) and northerly leg (stas. U-34 to U-55), to and from the South China Sea. Here larvae were predominant but, as in the north, juveniles were caught in moderate-to-high numbers, evidently indicating survival from the peak numbers of larvae observed in the same area (C) two months earlier.

These S-10 transects provided three sets of observations, more closely-spaced geographically than during the grid surveys. Temperature structure along the northern transect indicated stratification of the water column to the west and some downwelling to the east. Larvae were concentrated at stations U-65 and U-66, where the sub-surface 27.5°C isotherm bent upward and surface temperature was scarcely warmer.

To the south, sampling was across the front at which Gulf and South China Sea waters converge, as indicated by the vertical isotherms. Again larvae were concentrated at the 27.5°C isotherm in both instances. Salinity data were not obtained at these stations. An examination of the temperature and salinity characteristics of all other localities where substantial numbers of larvae were caught follows the description of *Pseudeuphausia's* distribution in the South China Sea.
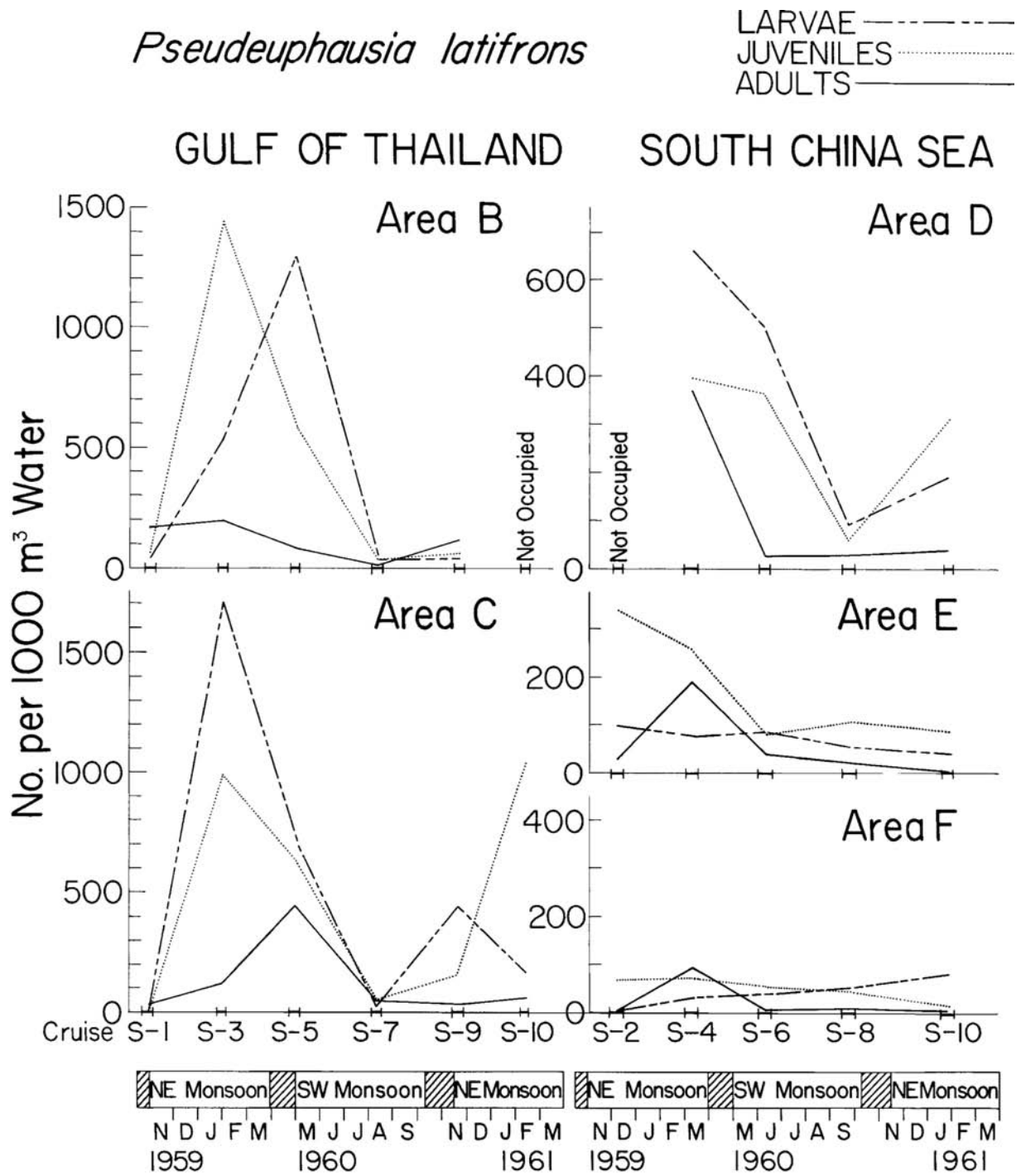
Figure 8. Abundance of *Pseudeuphausia latifrons*, larvae, juveniles, adults, by cruise and sea.
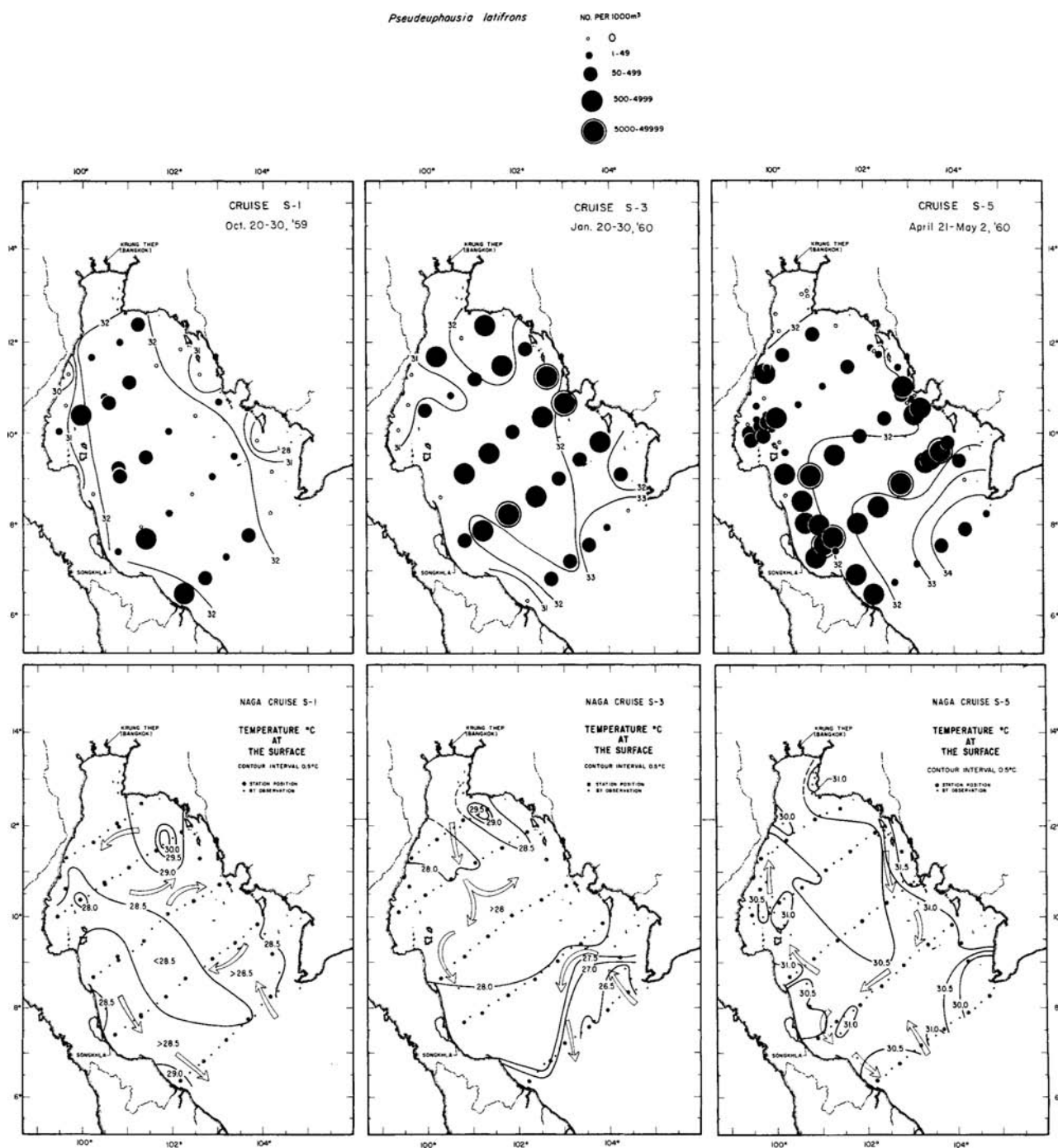
Figure 9. Above, *Pseudeuphausia latifrons* distribution, Gulf of Thailand cruises, S-1, S-3, S-5, with surface salinity isopleths. Below, surface isotherms and generalized surface circulation, from Robinson's description.

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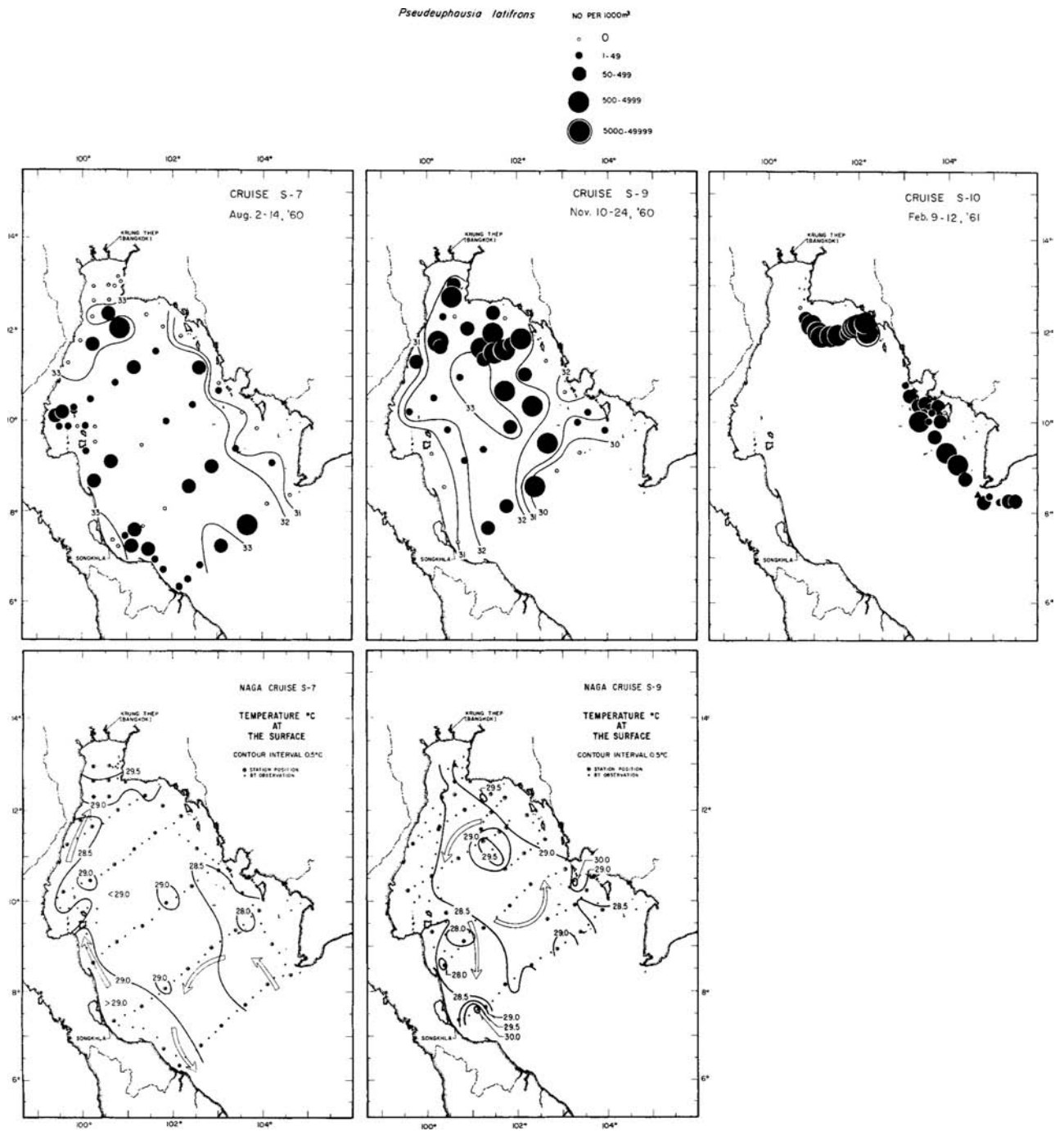
Figure 10. Above, *Pseudeuphausia latifrons* distribution, Gulf of Thailand cruises, S-7, S-9, S-10, with surface salinity isopleths. Below, surface isotherms, and generalized surface circulation, from Robinson's description.

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PSEUDEUPHAUSIA LATIFRONS, SOUTH CHINA SEA

Pseudeuphausia was widely distributed in the region during all seasons. Its particular association with the neritic waters is evident only when the overall abundance of the species (Fig. 13) is broken down into developmental groups (Figs. 8, 14-18). The centers of reproduction are evidently over the shelf.

November-December, 1959 (Cruise S-3) (Figs. 8, 14). Adults and larvae (1.5-3.5 mm) occurred extensively over the shelf to the south (area E), particularly inshore. Most larvae were in waters off the Mekong delta where salinities were high (33.0-33.6 ‰) and temperatures somewhat low (26.3-28.0°C). *P. latifrons* was low in density off Cape Camau where salinity was lowest, 31.6 ‰, and in the coldest (< 26.3°C) waters extending southward from Nhatrang to 10°N.

Adults were sparse over the deep basin, 8-12°N, where larvae were essentially lacking. Juveniles, though only in moderate numbers, were predominant over both the shelf and basin. Area D, inshore to the north, was not surveyed.

February-March, 1960 (Cruise S-4) (Figs. 8, 15). Adults and larvae were now concentrated nearshore toward the north (area D) particularly off Nhatrang where salinity was reduced (31.8-33.0‰
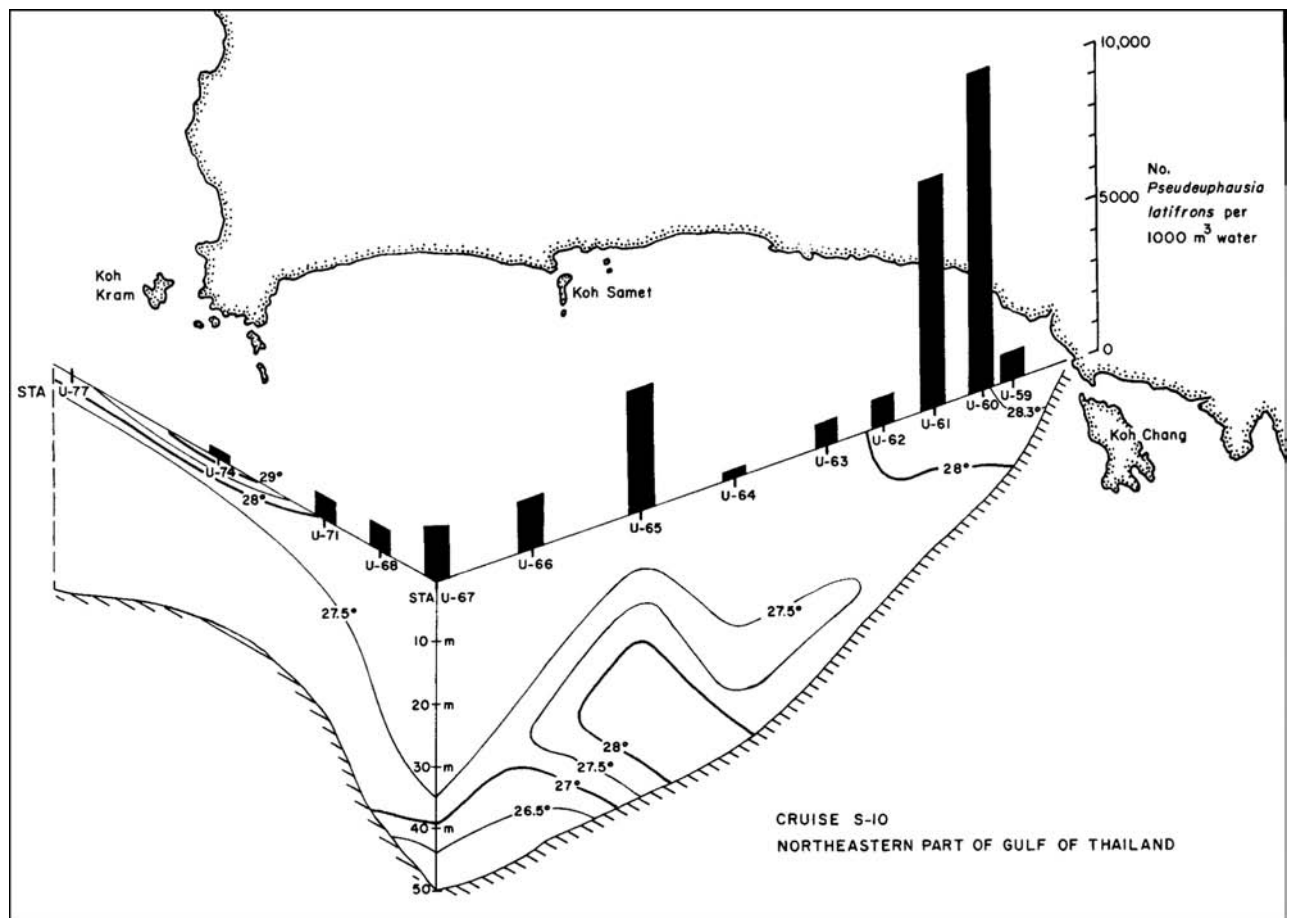
Figure 11. Abundance of *Pseudeuphausia latifrons* and temperature profile, inner Gulf transects cruise S-10.
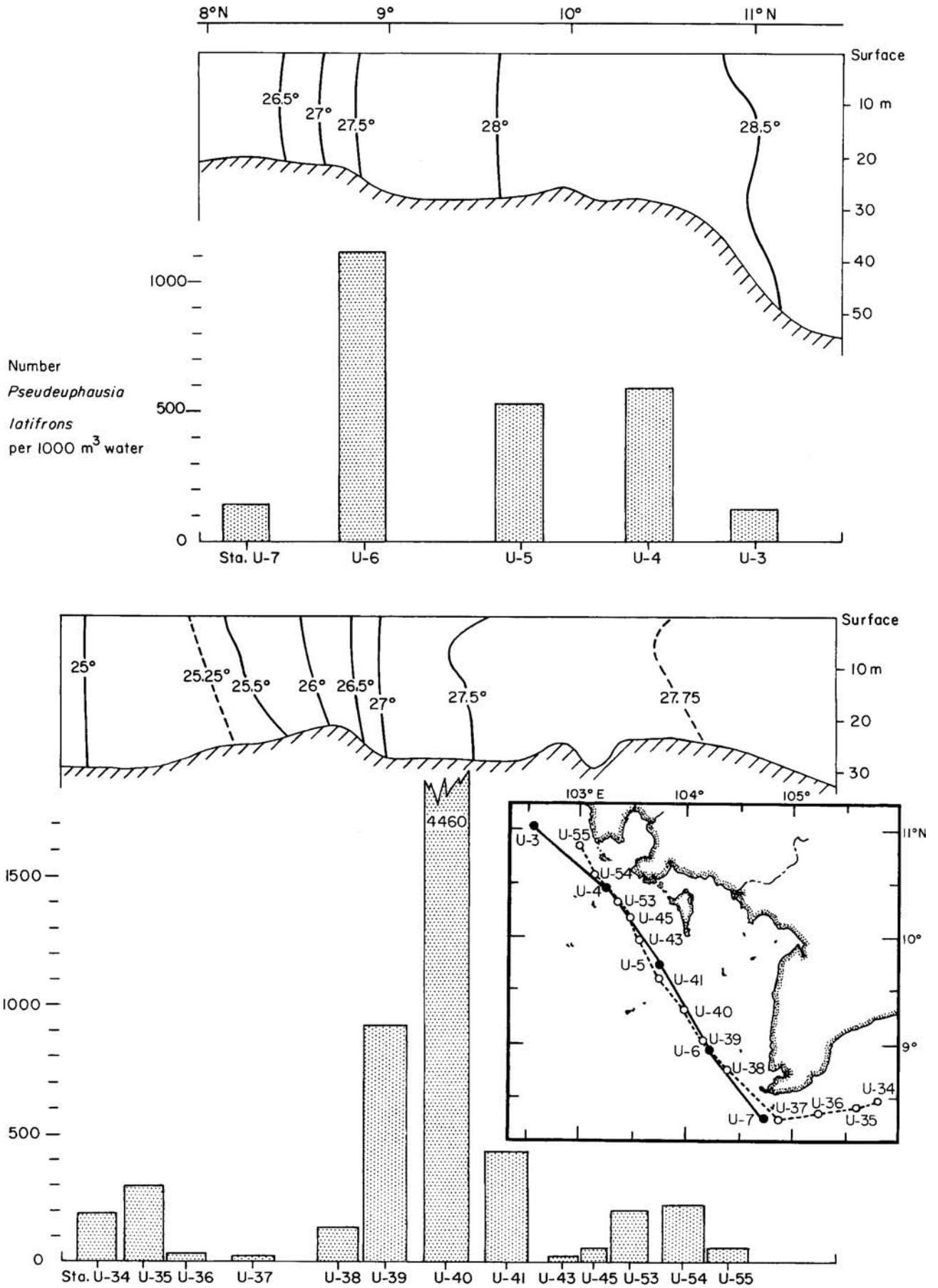
Figure 12. Abundance of *Pseudeuphausia latifrons* and temperature profiles, outer Gulf transects cruise S-10.
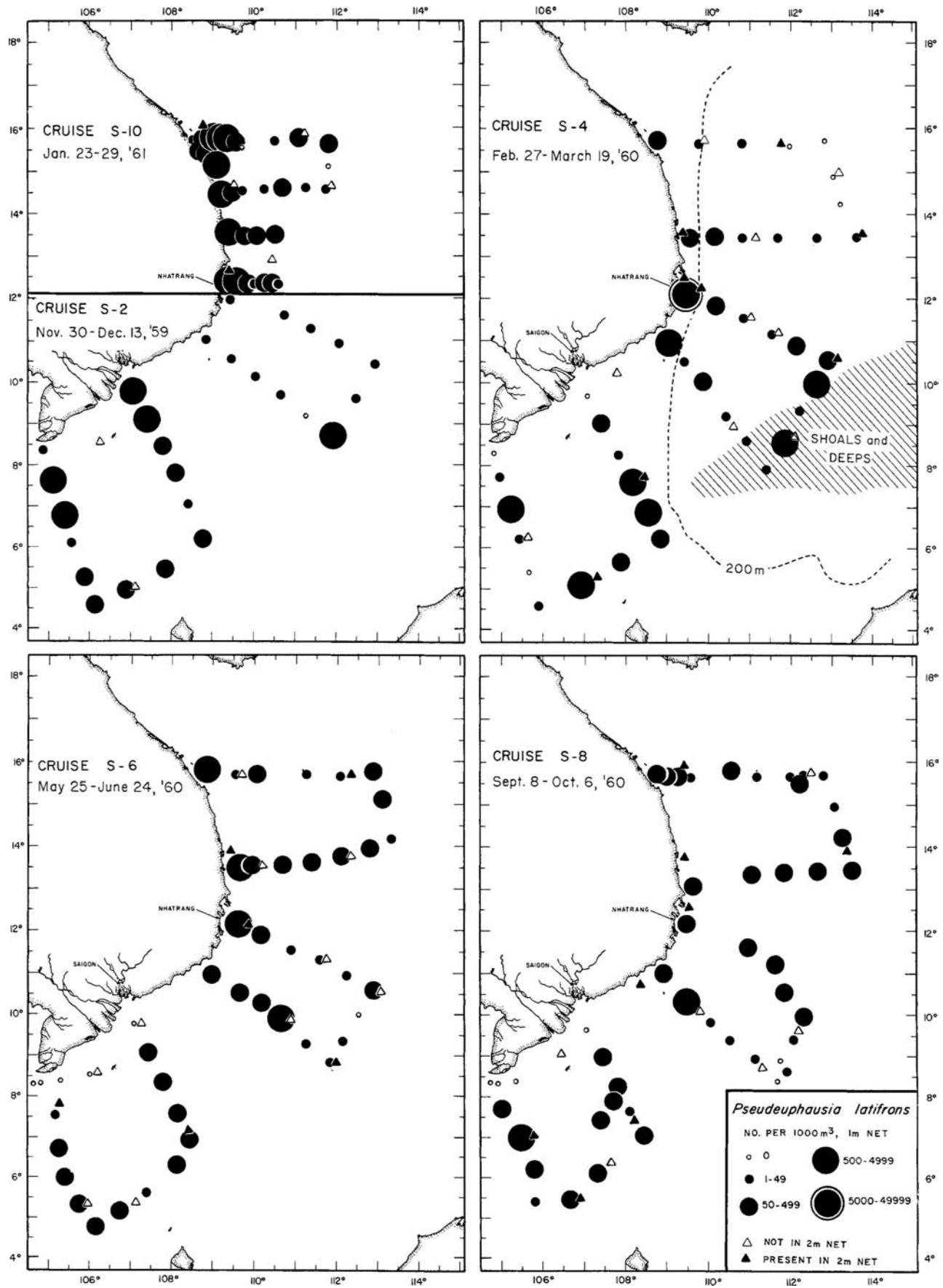
Figure 13. *Pseudeuphausia latifrons*, all sizes, South China Sea.

at the surface) but low temperature (23.5-24.5°C) indicated upwelling.

In the south (area E) all developmental stages were more restricted to the offshore region, avoiding the near-shore region where salinity was particularly high, 33.8-34.0‰. As during the previous cruise, adults and larvae were patchily scattered over the basin region and were generally in low density.

May-June, 1960 (Cruise S-6) (Figs. 8, 16). Adults were scarce, living mainly in a nearshore north-south belt. Small larvae, <2.4 mm (not separated from the 1.5-3.5 mm larvae in the counts for S-2 and S-4), were very scarce, occurring only at four scattered stations. 2.5-3.5 mm larvae were widespread but most dense nearshore toward the north (area D) where temperatures, though higher than during the northeast monsoon cruises, were cooler than offshore, 28°C as compared with 30-31°C.

Flow was now strong towards the northeast and 2.5-3.5-mm larvae (Fig. 16) and juveniles (Fig. 8) occurred extensively over most of the southern shelf (area D). However, *P. latifrons* was lacking at the two nearshore stations off the Mekong delta where surface salinity remained particularly high, no substantial runoff having yet taken place.

September-October, 1960 (Cruise S-8) (Figs. 8, 17). Along the coast, adults remained few in number but were now more evenly distributed. As in the previous two cruises, they were lacking at the stations nearest to shore in the south. The offshore spread of adults was broadest at the extreme north and south where the oceanic plankton community was weakest.

The smaller larvae (<2.5 mm) were present along the coast to the north of Nhatrang. Older larvae (2.5-3.5 mm) were widely distributed nearshore and offshore in the north. In the south they were densest in a narrower belt, continuing to avoid water of extreme salinities, now *low* along the Mekong delta-to-Cape Camau coast (30.6-31.0 ‰) at the end of the southwest monsoon rains. The same range of low salinity was observed nearshore on the northern line of stations where, however, adults, juveniles and larvae of *P. latifrons* were all found though in their lowest density of the year.

January-February, 1961 (Cruise S-10) (Figs. 8, 18). Only the northern areas D and F were sampled to any extent. Area E was represented by four stations far to the south, inshore.

Adults and juveniles were now strongly centered nearshore where upwelling and southerly flow were indicated by surface temperatures of 22-23°C, as compared with 24.0-25.5°C offshore. Inversion of nearshore salinities further indicated upwelling, and coastal surface values were 32-33 ‰, as compared with 33.6-33.8 ‰ over the basin.

The smaller larvae were in the same nearshore zone as adults, while the distribution of larger larvae was expanded over most of the area sampled. Larvae in general were increased in number over the previous inter-monsoon period, as were juveniles in the north. Adults remained constant in mean density.

In summary, *Pseudeuphausia* in the South China Sea passed through seasonal cycles of production and abundance (Fig. 8) similar to those observed in the Gulf of Thailand. Peak production of young took place during and immediately following the northeast monsoon season when adults were also at a maximum. This was more evident during 1959-60 than during 1960-61, perhaps due to differences in sampling. Though the main nearshore currents are southwesterly during this season, supported by northeast winds, the heavy coastal concentrations of *P. latifrons* in the south appeared to shift progressively northward from December (S-2) to March (S-4) to May-June (S-6) when they were to the north of Nhatrang. This probably reflects successive development at different population centers, rather than northward migration of a single population. Such development may be related to increased coastal fertility brought about by southerly flow from the Gulf of Tonkin and by upwelling along the northern coast during the northeast monsoon season.

There was a general decline in the population during May-September, though numbers of juveniles remained stable or even increased somewhat in the south (area E). During January-February, 1961, recruitment of larvae was again initiated, at least in the north. (Area E was
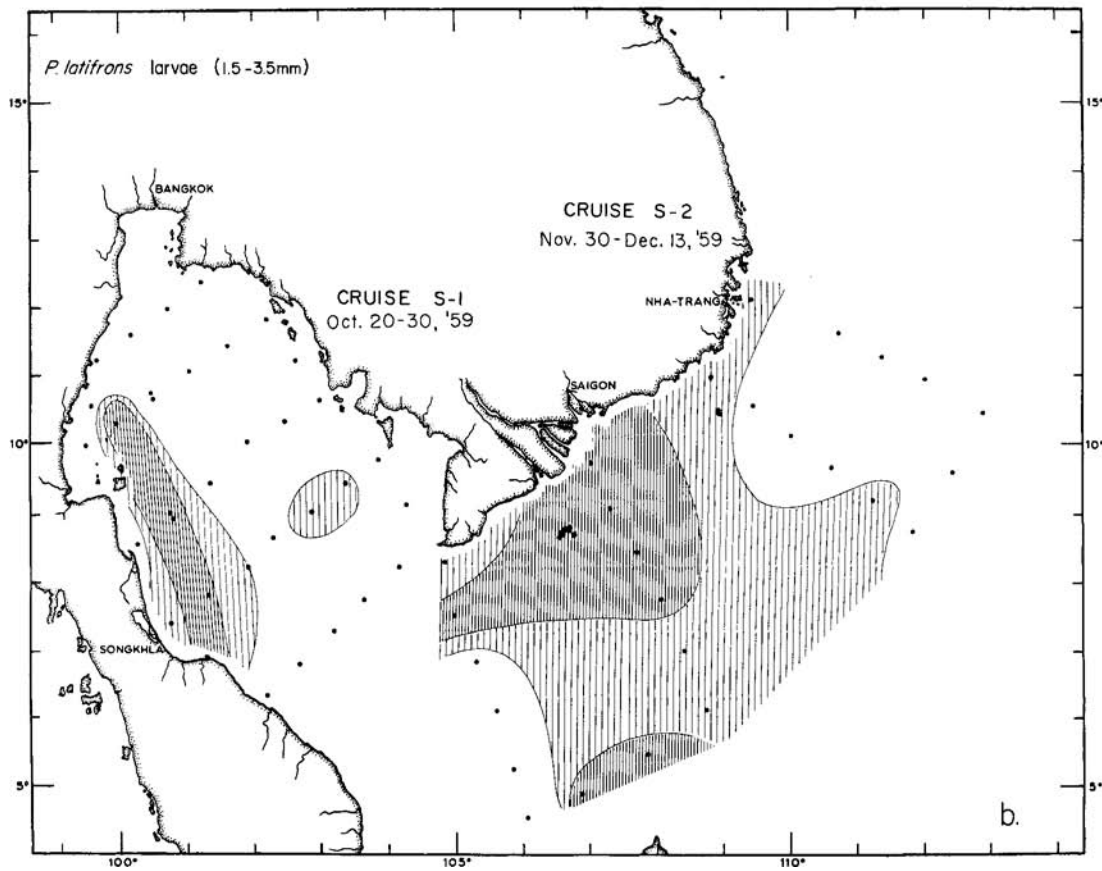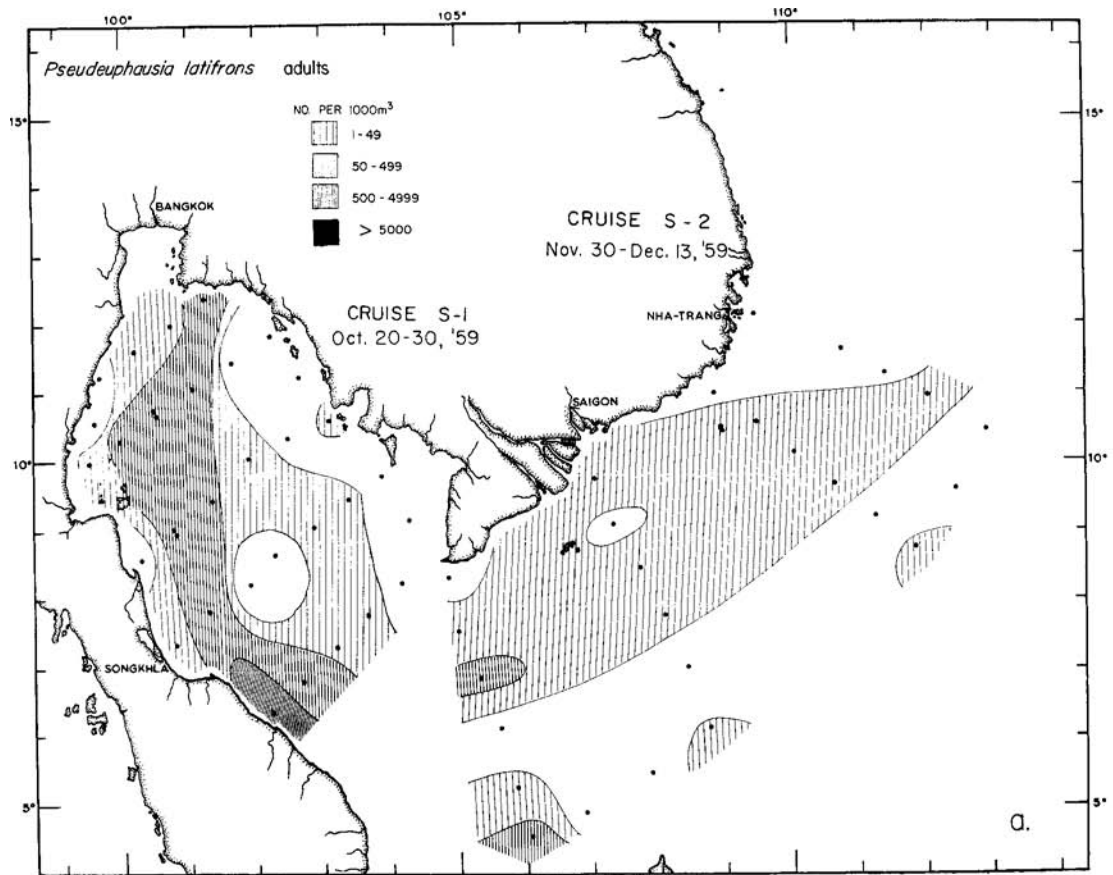
Figure 14. Distribution of *Pseudeuphausia*, cruises S-1, S-2. a) adults, b) larvae (1.5-3.5 mm)
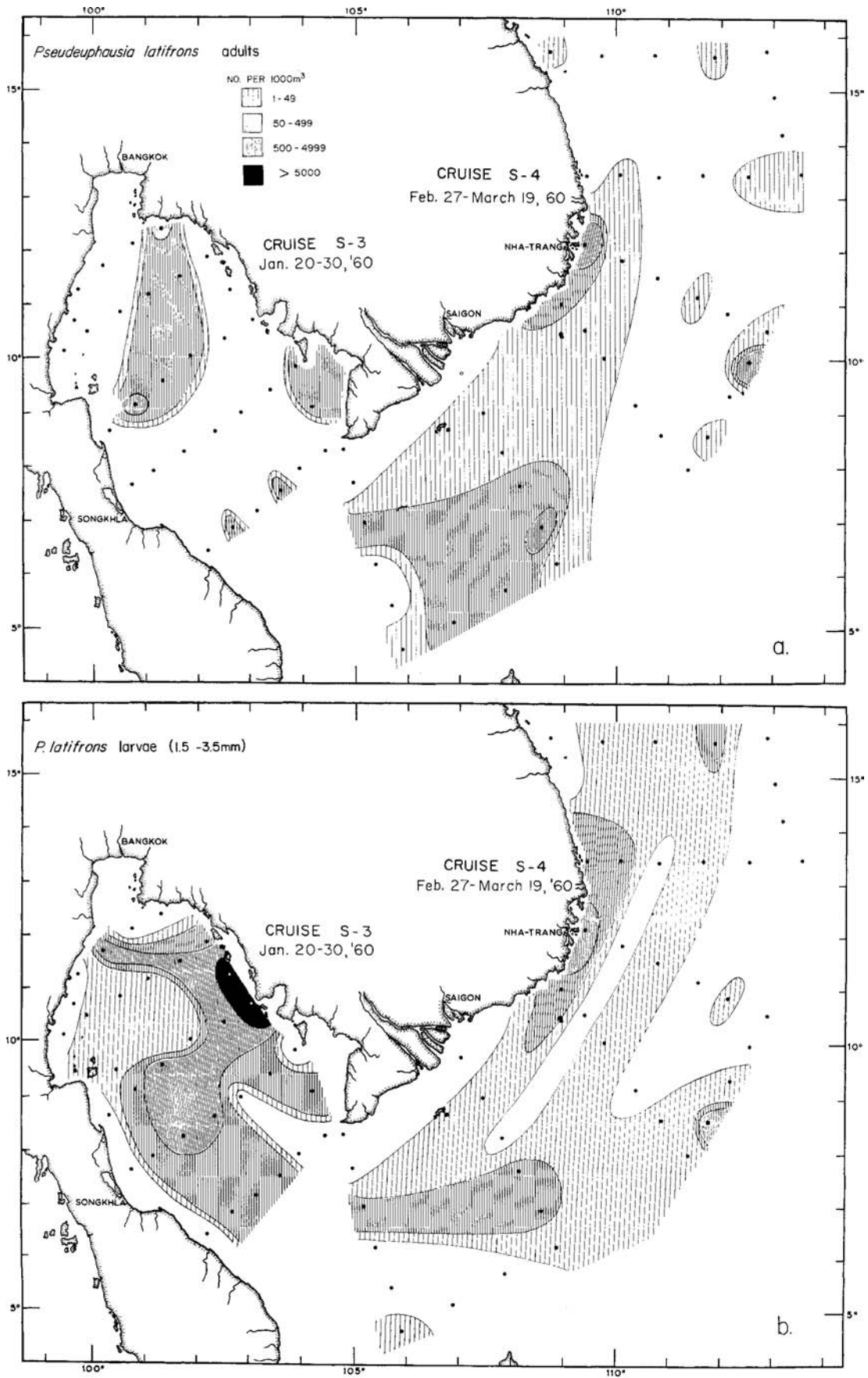
Figure 15. Distribution of *Pseudeuphausia*, Cruises S-3, S-4. a) adults, b) larvae (1.5-3.5 mm)
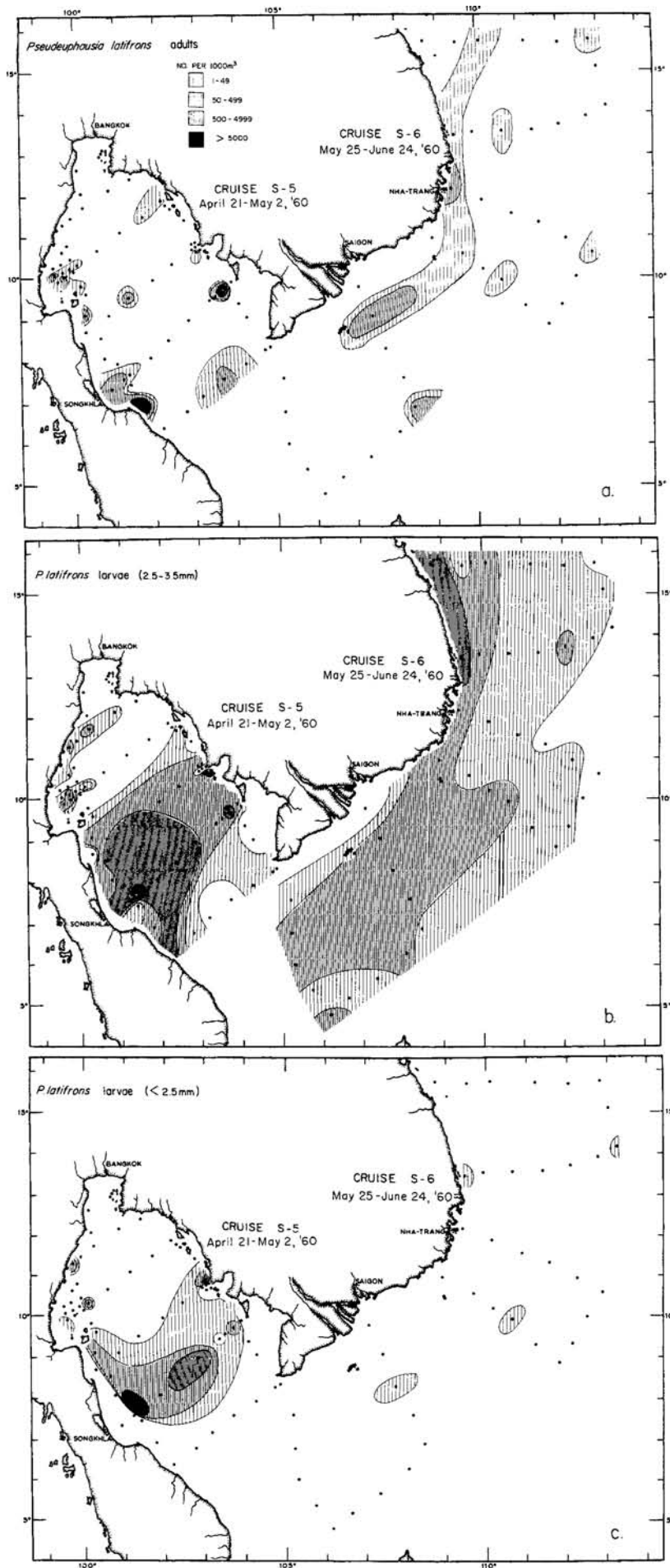
Figure 16. Distribution of *Pseudeuphausia*, cruises S-5, S-6. a) adults, b) larvae (2.5-3.5 mm), c) larvae (< 2.5 mm).
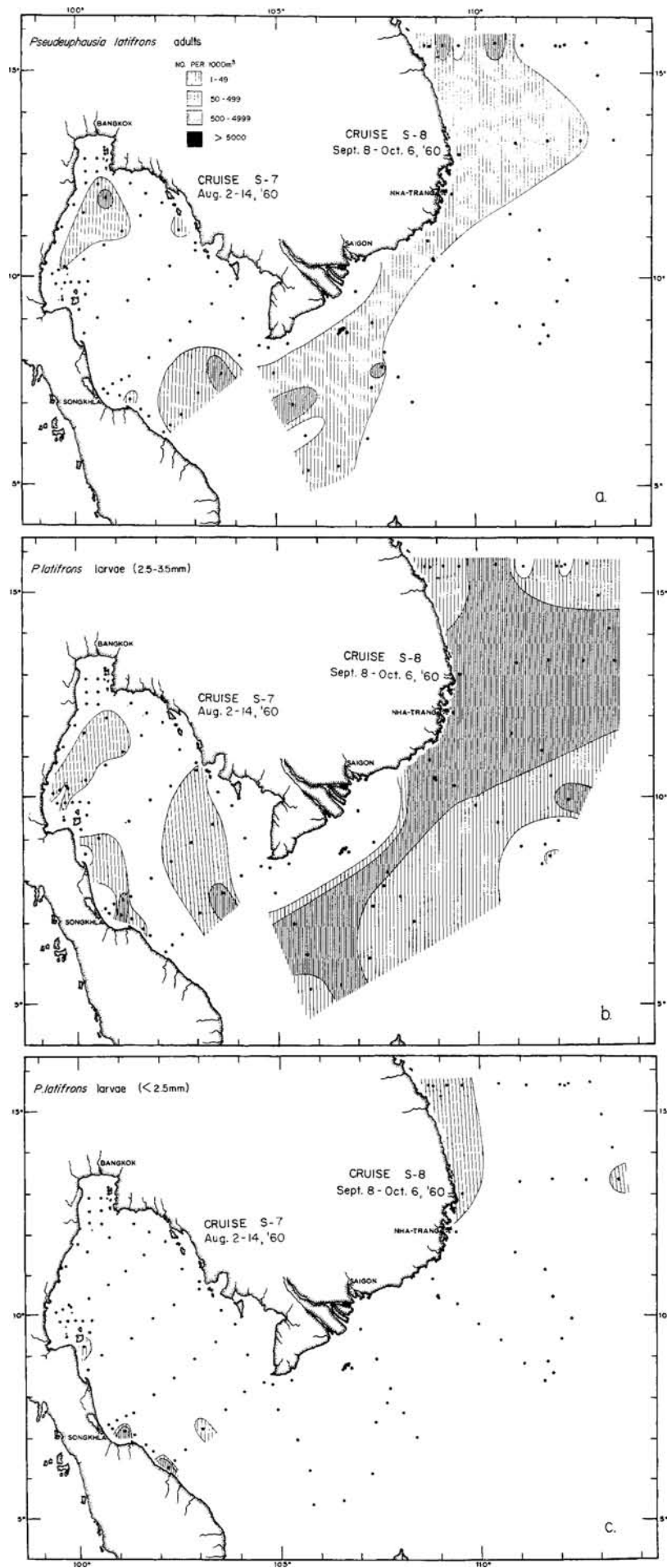
Figure 17. Distribution of *Pseudeuphausia*, cruises S-7, S-8. a) adults, b) larvae (2.5-3.5 mm), c) larvae (< 2.5 mm).
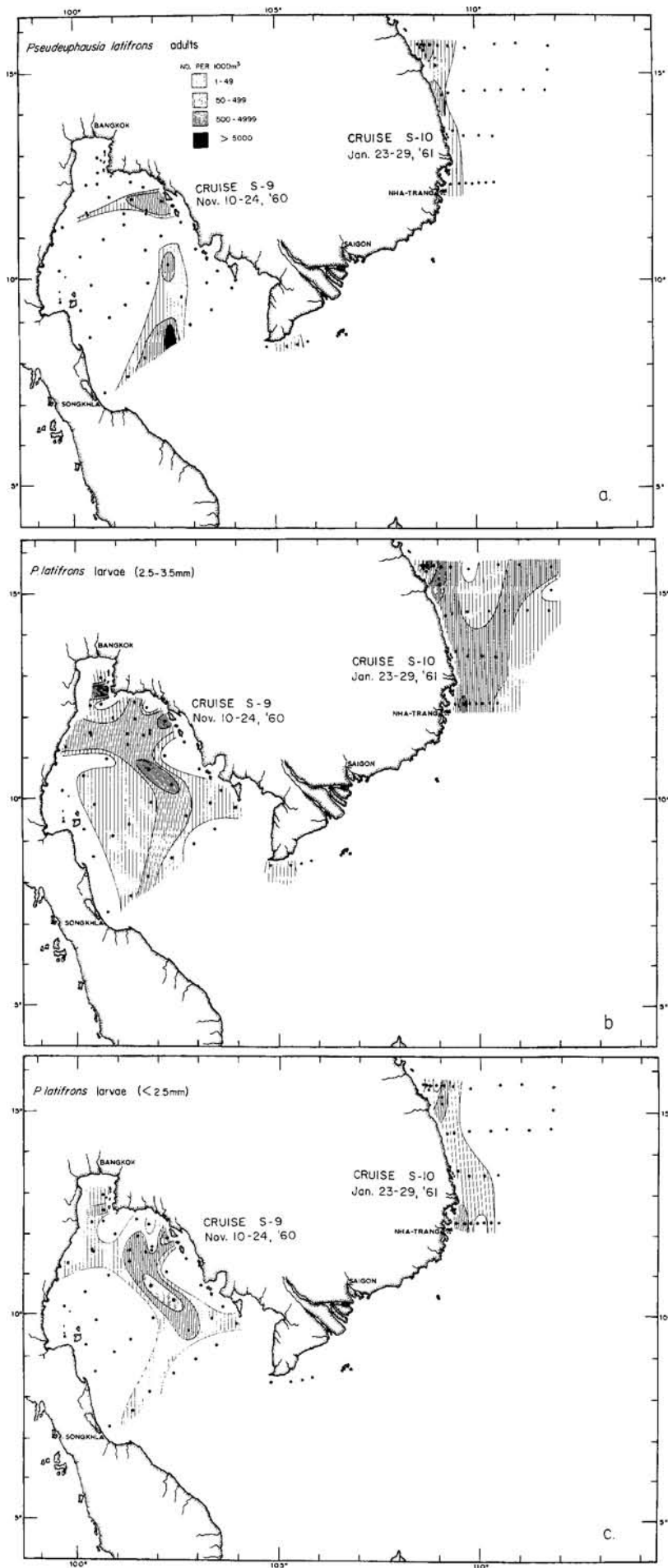
Figure 18. Distribution of *Pseudeuphausia*, cruises S-9, S-10. a) adults, b) larvae (2.5-3.5 mm), c) larvae (< 2.5 mm).

not then studied.)

Substantial dispersal over the deep basin of both developing larvae and more strongly swimming stages is evident with *Pseudeuphausia*. This suggests the possibility of substantial population loss if this species is dependent upon coastal waters for nursery areas and for optimal adult feeding. (Wickstead, 1961, noted it to be a daytime bottom or near-bottom dweller, and presumably feeder, off Singapore.) However, such loss is not expected to be extreme in a sea of this size, entirely bounded by coasts habitable by the species, in which gyres of circulation and reversals of flow prevail.

TEMPERATURE AND SALINITY CHARACTERISTICS
OF WATER FAVORABLE TO PSEUDEUPHAUSIA LARVAE

Stations at which densities of larvae were in excess of 100 per 1000 m^3 of water are here considered "favorable sites" for the larvae. Temperature and salinity values at 10 m depth are regarded as representative of these parameters in the near-surface habitat occupied by calyptopis and furcilia stages of *Pseudeuphausia*. This is an approximation of the depths occupied by these larval stages, and for epiplanktonic euphausiids in general (Brinton, 1967).

Ranges of the 10 m temperature and salinity values among 1) the favorable sites found for each cruise and 2) all stations for each cruise, are given in Figure 19. Table 1 includes, in addition, the means of "favorable" temperature and salinity and the values for these parameters at stations where the peak numbers of larvae occurred.

With respect to temperature, the favorable site range varied from cruise to cruise in the Gulf of Thailand, covering much of the prevailing overall range. The favorable site range was of the order of 28-29° C, except on cruise S-5 when the entire Gulf was warmer than 29.3°C at 10 m, and on cruise S-10 when the only area examined was in the north and particularly cool, 25.7-28.0°C. It may be significant that there were no favorable sites among the seven S-5 stations where temperature exceeded 30.8°C. The maximum temperature at 10 m among the other Gulf cruises was 29.7°C.

Temperatures in the South China Sea area were generally lower, with *Pseudeuphausia* larvae in excess of 100/1000 m^3 at values as low as 21°C and as high as 29.1°C. Only during S-8, when the southwest monsoon and accompanying northerly flow were at a height, was the temperature range at favorable sites found to be 28-29°C, the commonest range for the Gulf sites. Mean values varied between 26.2°C and 28.6°C, except during S-10, when only the cooler region north of Nhatrang was sampled. As in the Gulf, the places of highest available temperature (here >29.1°C) were in no instance at favorable sites for the larvae of this species.

In the Gulf the favorable site range of salinity extended through less of the available range than in the South China Sea. During four of the five Gulf cruises, areas of low salinity (< 31.3 ‰) existed, but evidently none were suitable for production of the larvae. In the South China Sea 10 m salinity was never less than 31.1 ‰, a value found at a favorable site for the larvae. Thus in the Gulf the range of values at favorable sites was 31.3-33.5 ‰, as compared with an overall range of 29.3-34.4 ‰. In the South China Sea, 31.1-34.4 ‰ could be "favorable," virtually the same as the available 31.1-34.5 ‰.

It may be concluded that, with respect to these two parameters, only low salinity, < 31.1 ‰, may be limiting to the recruitment or survival of these larvae. However, it must be remembered that *P. latifrons* ranges and reproduces throughout the region examined here, during one or another season. Here we may more reasonably search for optimal and minimal, rather than for limiting conditions. The 10 m temperature range of 27-30°C is found to be generally suitable for *Pseudeuphausia* larvae, as is the salinity range of 31-34 ‰.

The occurrence of substantial numbers of larvae in relatively cool (21.0-23.4°C) southerly flowing water in the northern part of the South China Sea survey area during cruise S-10 was anomalous. As was noted in the discussion of the geographical distribution of the species,

Table 1.

TEMPERATURE AND SALINITY (10m) RELATIONSHIPS OF PSEUDEUPHAUSIA LARVAE AT FAVORABLE SITES (STATIONS WITH >100 LARVAE PER 1000m^3)

Cruise	No. Stas.	At Favorable Sites				At Favorable Sites			
		Temp. Mean	Temp. at Peak No. Larvae	Temp. Range	Temp. Range All Stas.	Sal. Mean	Sal. at Peak No. Larvae	Sal. Range	Sal. Range All Stas.
Gulf of Thailand									
S-1	2	28.4	28.7	28.1-28.7	28.0-29.3	32.5	32.8	32.1-32.8	30.1-33.2
S-3	14	28.1	28.15	27.5-28.3	26.2-28.3	31.8	32.3	31.3-32.5	30.1-34.0
S-5	16	30.5	30.5	29.3-30.8	29.3-31.4	32.1	31.7	31.3-32.7	31.3-34.4
S-7	5	28.7	28.4	28.2-29.0	28.1-29.7	33.1	32.9	32.8-33.5	30.4-33.8
S-9	17	28.8	28.6	28.3-29.3	28.2-29.3	32.5	32.7	32.1-33.0	29.3-33.0
S-10	18	27.8	27.4	26.3-28.0	25.7-28.0				
South China Sea									
S-2	6	27.0	26.3	26.3-28.0	26.3-28.2	33.5	33.9	33.0-33.9	32.0-34.2
S-4	7	26.2	25.0	24.1-28.0	22.2-28.1	33.7	33.6	33.3-34.4	32.4-34.5
S-6	7	28.1	26.5	26.5-29.1	26.5-30.5	33.6	33.5	33.3-34.0	32.3-34.1
S-8	4	28.6	28.6	28.2-29.0	28.1-29.9	33.1	33.2	31.1-33.6	31.1-34.1
S-10	4	23.0	23.2	21.0-23.4	21.0-25.5	33.5	33.3	32.3-34.0	32.3-34.0
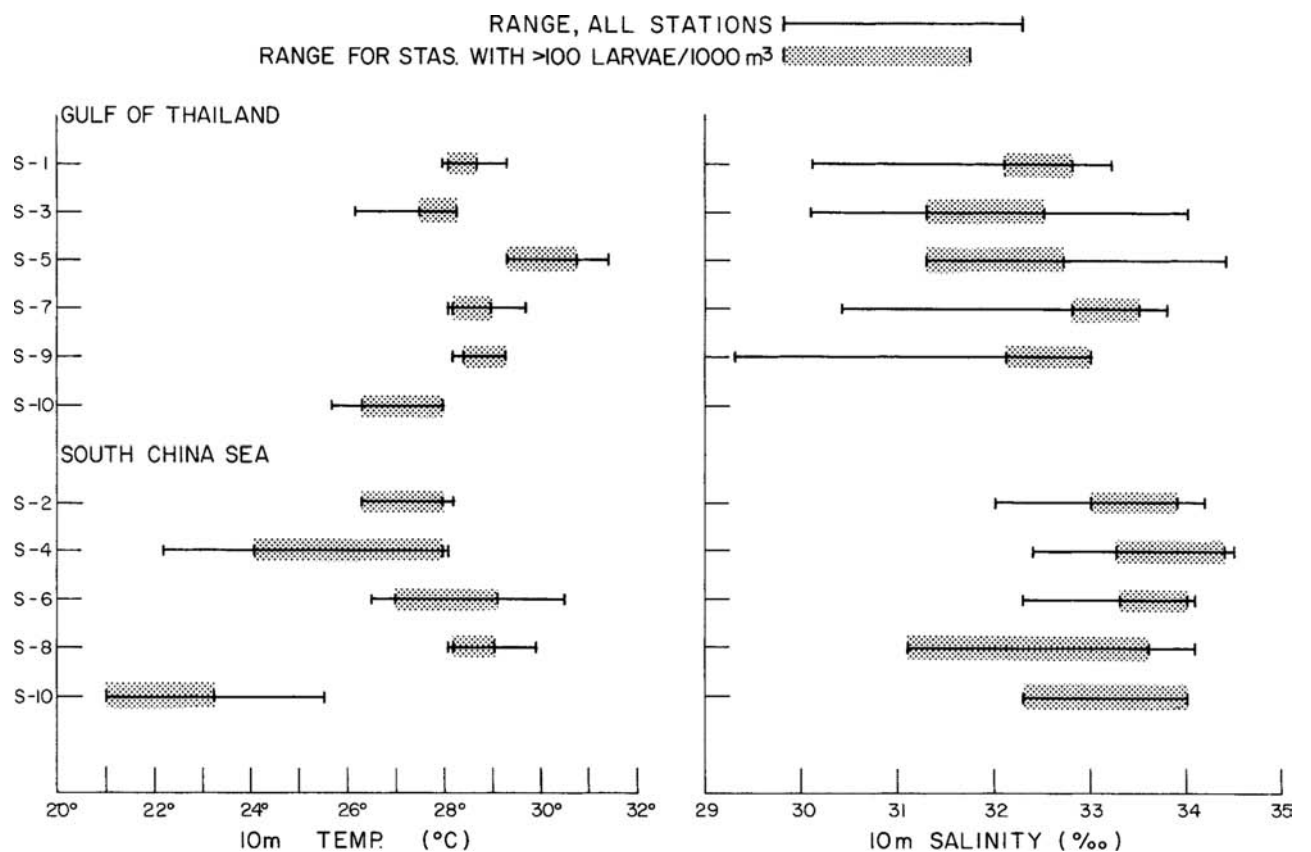
Figure 19. Temperature and salinity ranges (10 m depth) for localities favorable for *Pseudeuphausia* larvae, as a proportion of available ranges on each cruise.

these larvae were evidently unaccompanied by adults, probably deriving from a population center in the Gulf of Tonkin. There is the possibility that such a population is physiologically or even morphologically distinct from those centered on the Sunda Shelf, as a consequence of ecotypic adaptation or of intermittant geographical or reproductive isolation. This must be considered to be possible in the light of the identification of the Yellow Sea population to the north as a distinct species, *Pseudeuphausia sinica* (Wang and Chen, 1963).

The T-S characteristics of waters favorable and unfavorable to *Pseudeuphausia* larvae were examined to determine if there might be a better correlation than with either temperature or salinity alone (following the use of such near-surface T-S values by Bary, 1963). However, the values at the favorable sites yielded no regression, reducing only to the two extreme values of each of the two component parameters.

OCEANIC EUPHAUSIIDS OF THE SOUTH CHINA SEA BASIN

The South China Sea is the largest of the inter-ocean seas. During the northeast monsoon (October-March) waters enter from the Pacific between Taiwan and Luzon. The superficial water derives mainly from the Kuroshio, but this is mixed in these latitudes (20°N) with even higher salinity water from the west (34.2-34.6 ‰). This latter is evidently the source of certain Pacific Central species, e.g., *Euphausia mutica* (Fig. 52) and *Stylocheiron suhmii* (Fig. 66) which occur in low density in the northern part of the South China Sea, together with the predominantly equatorial fauna evidently maintained locally and supplemented from the Kuroshio.

This Pacific water spreads westward south of Taiwan, decreasing in salinity as it moves southward along the coast of Viet Nam while mixing with local waters. During the northeast monsoon season, the mixed layer is 70-100 m thick in the prevailing southerly current which persists across the Sunda Shelf and Java Sea, and then swings eastward to the Flores and Banda Seas

With the beginning of the southwest monsoon in May, and the onset of rains as far north as the mid-part of the South China Sea, the salinity decreases, and the high salinity waters are forced back to the north as the circulation of the region reverses. The homogeneous layer thins to about 40 m.

In the central parts of the South China Sea, countercurrents exist during both seasons (Figs. 1a, b, 22), diminishing the effect of one-way transport on the plankton and the conservative physical properties. The overall salinity change, for example, is less than 0.7 ‰. During October-March the circulation over the sea's basin is counterclockwise or cyclonic. During May-September the circulation is clockwise. Both systems serve to maintain the oceanic species in the basin, their populations apparently not being carried in any abundance or for much distance into shelf waters to the southwest. On the other hand, the neritic species are consistently rather widely dispersed in the homogeneous layer over the basin of the South China Sea during periods of both northerly and southerly flow.

Species Distributions. Only the western half of the South China Sea was the object of study by the Naga Expedition. Somewhat more than half of this area lay over the sea's basin. The continental slope delimiting the basin is indicated by the 200 m depth contour included on the distribution charts (Figs. 25-44). It is to this deep-water region that the distributions of the oceanic species are clearly tied. The winds, the temperature structure of its water mass and the patterns of upper-level currents have been described on the basis of Naga data (La Fond, 1963). These were summarized in the preceding section describing biomass distribution.

Euphausiids made up 5-10% of the plankton biomass occupying the South China Sea basin (area F), expressed also as grams per 1000 m^3: S-2, 7.4% (2.5 g): S-4, 10.0% (4.7 g); S-6, 7.3% (3.2 g); S-8, 5.3% (3.6 g); S-10, 8.4% (4.2 g). When the entire South China Sea survey region was considered as a unit (areas D, E and F combined) the average euphausiid component of the biomass was reduced to a minimum of 1.9 g (S-2) and a maximum of 4.3 g (S-4). This results from introduction of low values from the neritic areas, comparable with the values of 0.2-3.9 g/1000 m^3, or 0.005-1.5% of the biomass, observed in the Gulf of Thailand.

Abundances of the larvae, juveniles, and adults of the oceanic species were determined (Figs. 20, 21, Appendix II). Seasonality in these values is discussed under "Recruitment," below. These are expressed as means per standard station, based on all stations at which the species was present. Comparable values for cruise S-2, areas D and F, may be most poorly estimated because the two northern lines of stations which extend mainly over the basin were not then occupied. Values for S-10, though derived from a special northern sampling grid, may be comparable with those for S-4, S-6 and S-8, because equal numbers of area D and area F stations were occupied.

The basin community is fundamentally different from that of the neritic waters, and the two retain a high degree of individuality in spite of the seasonal reversal of surface transport, southward toward, then northward away from the Sunda Shelf at the south. The basin sustains

relatively more species but has a much lower biomass (Fig. 2). However, owing to its predominantly crustacean character, the oceanic plankton may still be regarded as rich potential nutrient and as more suitable support for large predaceous fishes, e.g., tunas (Roger, 1973c) than for grazers, e.g., the mackerel *Rastrelliger*, mainly a neritic fish (Matsui, 1970).

The offshore oceanic group includes twelve predominant species, regular in occurrence and reproducing locally throughout the year. Of these, the four *Euphausia* species are representative of different taxonomic groups within the genus (see taxonomic section); in the broadest faunistic sense they are also of four groups: *E. diomedeae* is oceanic equatorial Indo-Pacific, *E. sanzoi* is a boundary or slope species of the tropical western sides of the Pacific and Indian oceans, *E. pseudogibba* is narrowly tropical in all three oceans but closely linked with waters of the Indo-Australian Archipelago as it is with the Caribbean in the Atlantic, and *E. tenera* is a warm-water cosmopolite. Two species are from different subgeneric groups in *Thysanopoda. T. tricuspidata* and *T. aequalis*, both widely ranging tropical-subtropical species. Two are from different groups in *Nematoscelis: N. gracilis*, an Indo-Pacific equatorial species and *N. microps* which is tropicalsubtropical in all oceans. In all these species, the larvae are believed to live above about 50 m depth, day and night, while juveniles and adults migrate into the surface layer at night from daytime levels of 200-500 m (Lewis, 1954; Brinton, 1967).

The four other abundant species are in the genus *Stylocheiron. S. carinatum* is not closely related to the three "S. longicorne group" species (see taxonomic discussion) in each of which the adults occupy a different depth stratum: *S. longicorne*, two forms combined (deeper part of the thermocline) and *S. affine*, two forms combined (upper part of thermocline) (Brinton, 1967; Youngbluth, 1975), and *S. microphthalma* (above thermocline) (Brinton, personal obs.). The first three of these species are warm-water zone cosmopolites, *ca* 40° N-40° S. *S. microphthalma* is an equatorial Indo-Pacific species.

Thus, though the South China Sea oceanic group is somewhat diverse faunistically, the species all differ with respect to phylogenetic affinity, and hence, presumably, in habitat niche, or with respect to depth of water occupied. They are therefore regarded as elements of a regional community. *E. sanzoi* is the most irregular in occurrence and abundance. As will be mentioned in the discussion dealing with distribution, this may be essentially a swarming, slope-dwelling species, less a part of the basin assemblage than the other species.

Three euphausiid species were regular in occurrence, strongly associated geographically with the basin community, but almost always in very low density. These were *Thysanopoda monacantha, Nematoscelis tenella*, and *Stylocheiron abbreviatum*. Adults of these species were rarely caught by the 1-m net (none in the case of *T. monacantha*). It is probable that this sampling procedure was inadequate for them (Fig. 21), inasmuch as they were regularly caught by the 2-m net towed to depths of 400-800 m (Appendix IV).

As in other parts of its distributional range, *Nematobrachion flexipes* was found here to be sparse and irregular in occurrence.

Seven mesopelagic and bathypelagic species, though apparently permanent residents of the basin, were infrequently caught in the standard 1-m net tows (more commonly in the deeper 2-m net tows, Appendix IV), doubtless owing to the relatively great depths at which all of their life stages live (Brinton, 1962a, 1967): *Thysanopoda orientalis, T. pectinata, T. egregia, T. cristata, Nematobrachion boöpis, Stylocheiron maximum* and *S. elongatum*.

A few species were clearly expatriots, transported into the basin region (see Appendix III) from other geographical areas, as evidenced by the lack of reproduction locally. Six of the seven such species are elements of what has been called the Pacific's central water mass euphausiid assemblage (Brinton, 1962a): *Euphausia mutica, E. recurva, E. hemigibba, Nematoscelis atlantica, Stylocheiron affine* (Central Form), and *S. suhmii*. These were most broadly distributed in the basin area during the northeast monsoon season of southwesterly flow (Figs. 28, 38, 41).

The seventh presumed expatriot, *Euphausia similis*, though rare, was caught during all of the South China Sea cruises, usually by use of the large 2-m net. The peculiar range of this species is discussed in the section dealing with broader aspects of distribution and is given in Figure 55.

E. similis reproduces in the East China Sea, north of Taiwan. Juveniles and adults range southward through the deep basins of the Indo-Australian Archipelago to the equatorial Indian Ocean, another reproductive area. However, its South China Sea population, like those of the other oceanic species, appears not to extend over the Sunda Shelf to the south. A single furcilia larva was caught at each of two stations on the northernmost line (16°N) over the basin, indicating at least some reproduction not far to the north, possibly inside the South China Sea.

Seasonal changes in distribution show similarities among the oceanic species. The distributional changes appear related to direction and intensity of horizontal transport, which affect the extent to which there is movement into or away from 1) the Sunda Shelf waters in the south by basin residents and 2) the basin area in the north by expatriots from the oceanic Pacific to the northeast. Recruitment, on the other hand, appears to have been more influenced by factors controlling the vertical movement and mixing of waters, hence their productivity.

Stylocheiron carinatum is the most abundant species here as it is in many parts of the tropical-subtropical world ocean. During the northeast monsoon season of southerly flow (S-2, S-4), it ranged to the southernmost stations sampled, 5°N, 200 km beyond the basin (Fig. 37). It may then have ranged even further to the southwest. During May-June (S-6) at the onset of northeasterly flow it was displaced from the most southern stations of the shelf, and was now present somewhat to the northwest, 7°N, within 100 km of Cape Camau. This suggests that the NE-SW band of distribution over the shelf had shifted laterally northward, while probably still extending farther west than the plotted distribution shows. The possibility of such shift is supported by the appearance of *S. carinatum* in the Gulf of Thailand (its only appearance there) during the subsequent Gulf cruise (S-7) seven weeks later. Transport of this species was evidently by means of northerly flow into the Gulf (see discussion of Gulf euphausiids, p. 28, and Fig. 37). At the end of the southwest monsoon season (S-8) *S. carinatum* remained in substantial numbers over the northeastern part of the shelf, well to the south, 5° S.

More restricted to the basin proper was a group of nine species which appeared over the edge of the southern shelf only during the period of southerly flow, December-March (S-2, S-4):

> *Thysanopoda tricuspidata*, abundant over margin of shelf during S-2, much less frequent during S-4 (Fig. 25).
>
> *T. monacantha* and *T. aequalis* equally sparse over shelf during S-2 and S-4 (Figs. 26, 27).
>
> *Euphausia diomedeae*, farther south during S-2 than S-4 (Fig. 29).
>
> *E. tenera*, reaching as far as Cape Camau and to the south of it during S-2, sparser during S-4, and present at one station over shelf during S-6 (Fig. 33).
>
> *Nematoscelis gracilis*, almost as extensive in south as *E. tenera* during S-2, retreating somewhat (also like *tenera*) during S-4 (Fig. 35).
>
> *N. tenella* and *N. microps* equally sparse over shelf during S-2 and S-4 (Figs. 34, 36).
>
> *Stylocheiron abbreviatum*, one record over shelf during S-2 and one during S-4 (Fig. 44).

The above group consists of species which, as adults and juveniles, either perform substantial diurnal vertical migrations (all except *S. abbreviatum*), descending from the surface layer to depths of 200-500 m at night, or permanently occupy a subsurface stratum (*S. abbreviatum* which lives at depths of 100-200 m, Brinton, 1967, and 100-500 m, Baker, 1970). Evidently the shelf waters are not deep enough to sustain the older stages. The specimens of these oceanic species found over the shelf were, except for some adults of *E. tenera*, consistently larvae and young juveniles which show tolerance of the neritic environment. This tolerance diminishes with distance from the basin habitat, and is maximal in the case of *S. carinatum*, the young stages of which are particularly abundant here and live at all depths above 100 m. It is minimal in the case of *S. abbreviatum*, the young stages of which live in the mixed layer but not in the uppermost parts of it.

Circulation above *ca.* 75 m depth may be independent of the proximity of the sea floor, and hence may carry epipelagic plankton across the continental slope, onto the shelf or into the basin depending upon the season. Deeper circulation must necessarily conform to the bathymetric

contours of the basin. Thus, the entire population of *Stylocheiron longicorne* (Fig. 43) is retained in the basin, its depth range being in and somewhat below the thermocline (100-300 m, off California). *S. abbreviatum* is almost restricted to the basin.

The only oceanic species found at localities over the shelf during all four cruises belonged also to the genus *Stylocheiron*. These were *S. microphthalma* (Fig. 42), *S. affine* West Equatorial Form (Fig. 39) and *S. carinatum*, discussed above. From the standpoint of vertical distribution, these species are the most clearly epipelagic in the genus. This characteristic, in conjunction with the non-migrating habit of the genus as a whole, provides them with at least a temporary ability to tolerate slope and shelf waters. It is to be remembered that the other oceanic species occurring over the shelf were represented there also by non-migrators, their larvae and post-larvae.

Support for the concept of a basin-wide assemblage of species is to be found in records obtained by the Scripps Institutions's Circe expedition in the southeastern part of the South China Sea off Borneo. These localities are indicated on the distributional charts showing the entire region of the archipelago and lie 1) over the basin to the east of the line of Naga stations extending southeastward from the Mekong delta and 2) over the shelf at 2½°N and 3½° N, west of Borneo.

Samples from these basin stations contained all the species regarded as oceanic in the Naga survey area, both the abundant and the low-density species, e.g., *Thysanopoda tricuspidata* (Fig. 45) and *T. monacantha* (Fig. 47). In addition, the mesopelagic species *T. orientalis* (Fig. 48), *T. pectinata* (Fig. 46) and *Nematobrachion boöpis* (Fig. 64) were found in deep midwater trawl samples from this southern part of the basin.

As at the shelf stations off Viet Nam, those off Borneo provided evidence of shelf transgression by oceanic species, in the form of *Stylocheiron carinatum* (to 2½° N) and *S. affine* I-A Form (to 3½° N).

Distinguishing this southeastern part of the South China Sea from the Naga region is the appearance of *Euphausia sibogae* at the basin stations off Borneo. This population is apparently connected with that in the Sulu Sea and the Philippines, to the east and northeast. The scarcity of *E. sibogae* in the South China Sea (it was lacking off Viet Nam) and the absence of the even more regional species of the archipelago, *E. fallax, Nematoscelis lobata, Stylocheiron insulare* and *S. indicus*, argues for a close relationship of the South China Sea basin waters with the tropical oceanic Pacific to the northeast, rather than with the other semi-isolated basins of the archipelago to the east.

Recruitment. In an earlier section including figure 8, it was seen that the neritic species *Pseudeuphausia latifrons* produced maximum numbers of larvae during December-March in each of the coastal regions studied except the western side of the Gulf of Thailand. There the peak occurred at the end of the northeast monsoon season, April-May. The region of lowest population density was the basin of the South China Sea. Nevertheless, *P. latifrons* occurred there in numbers comparable with the oceanic species. It was noted, further, that *P. latifrons* apparently did not reproduce in the basin waters, as evidenced by the occurrence of the smaller (2 mm) larvae only in shelf waters. The older (3 mm) larvae were more widely dispersed, occurring in the basin waters as well, with maximum numbers appearing in December-March, as elsewhere (Fig. 8).

The annual reproductive cycles of the oceanic species were like that of *P. latifrons*, with larvae produced year-round but with the maxima falling during, or at the end of, the northeast monsoon period. This is the season of maximum incursion of oceanic Pacific water into the South China Sea basin, and is when the species ranges are most expanded in the direction of the southwesterly course of the wind-driven currents. Cruise-to-cruise abundances of the larvae, juveniles and adults of these species are plotted as mean values based on all stations at which the particular species occurred (Figs. 20, 21, Appendix II).

The most abundant species, *Stylocheiron carinatum*, showed maxima in larvae and juveniles during February, 1960 (S-4), and December-January, 1961 (S-10), with the adult maximum in between, May, 1960. *Euphausia diomedeae*, second in abundance, reproduced most heavily

somewhat later, in May (S-6), though larvae were in substantial numbers at all times. As in the case of *S. carinatum*, the peak of numbers of juvenile *E. diomedeae* coincided with that of the larvae. Adults were in even abundance throughout the main reproductive period, March to September.

Thus there were differences between the two commonest species with respect to the seasonality of the developmental phases distinguished. These may be explained by the differences in their reproductive and larval biology. The female of *S. carinatum* (as do all *Stylocheiron* species) carries her eggs attached to the thoracic limbs until they hatch. The eggs in a brood are few, 30-40 (Ponomareva, 1969). The calyptopis larva appears fat and a translucent yellow throughout the body, evidently retaining a substantial amount of oil. *S. carinatum* larvae were mainly produced during winter months when the surface layer of the sea was strongly mixed by northeast winds, and primary production would be low.

In contrast, *E. diomedeae*, like all *Euphausia* species, sheds her eggs directly into the water after fertilization, Ripe eggs number 50-200 (pers. obs.). The *Euphausia* calyptopis is slender and the mouthparts appear to be functional at the initiation of this developmental phase, judging from critical observations made on other *Euphausia* species, e.g., *E. gibboides* (Knight, 1975). *E. diomedeae* larvae were most abundant following the April inter-monsoon period of diminished winds, increased stability in the water column, and anticipated increase in primary productivity.

The high proportion of larvae to juveniles and adults in *E. diomedeae* as compared with the low proportion in *S. carinatum* (Fig. 20) may be attributed either to better survival in *S. carinatum* or to a shorter larval life.

The other *Stylocheiron* species, *S. microphthalma*, *S. affine*, and *S. longicorne*, showed maxima in larvae during the February, 1960, cruise, as was the case with *S. carinatum*. Numbers of larvae of these species also tended to increase at the end of the southwest monsoon season (S-8) and during the succeeding northeast monsoon period (S-10).

The picture in *Nematoscelis* was similar to that observed in *Stylocheiron*. Larvae of *N. gracilis* were more numerous by a factor of 2 during March, 1960 (S-4), over the previous and following cruises. This peak was followed by a clear maximum in juveniles 2½ months later. *N. microps* larvae were barely increased during March (S-2), being maximal when *N. gracilis* larvae were minimal, September to January. The picture in *N. tenella* is comparable, but it is less clear, owing probably to the low density of the species.

Thysanopoda tricuspidata showed a tendency toward high recruitment during and following the northeast monsoon season of 1959-60 but not during that season in 1960-61. *T. aequalis* showed an increase during both.

In addition to *E. diomedeae*, two *Euphausia* species were abundant in the South China Sea area. As in *E. diomedeae*, both provided pictures of seasonality in abundance that are aberrant for the basin assemblage as a whole. The S-2 and S-4 samples yielded few *E. sanzoi* larvae, as compared with those from S-6, S-8 and S-10. Juveniles were found mainly in March (S-4) and September (S-8). Adults were all but lacking in the standard samples obtained during all cruises but were caught by the large 2-m net. The apparent randomness of the occurrences of this species with respect to spatial distribution is like that observed with respect to time, suggesting that *E. sanzoi* lives in inadequately sampled swarms.

E. tenera peaked in larvae and juveniles during November, 1959 (S-2), declining in recruitment as the northeast monsoon season developed. No return to that level was apparent a year later (S-10). Adults remained constant in number during the course of the four surveys.

All other species were insufficient in numbers to consider with respect to seasonality in the abundance of life stages.

Relationships of the occurrences of larvae with water temperatures were unclear. For the abundant species, favorable sites for larvae (as defined for *Pseudeuphausia*, above) extended over nearly the full range of available temperatures (10 m depth) to be encountered while inhabiting the basin area. For *Stylocheiron carinatum* they were as low as 23.6-25.5° C (S-10) and as high as 26.8-30.3°C (S-6). However the season of relatively low abundance of larvae, May to
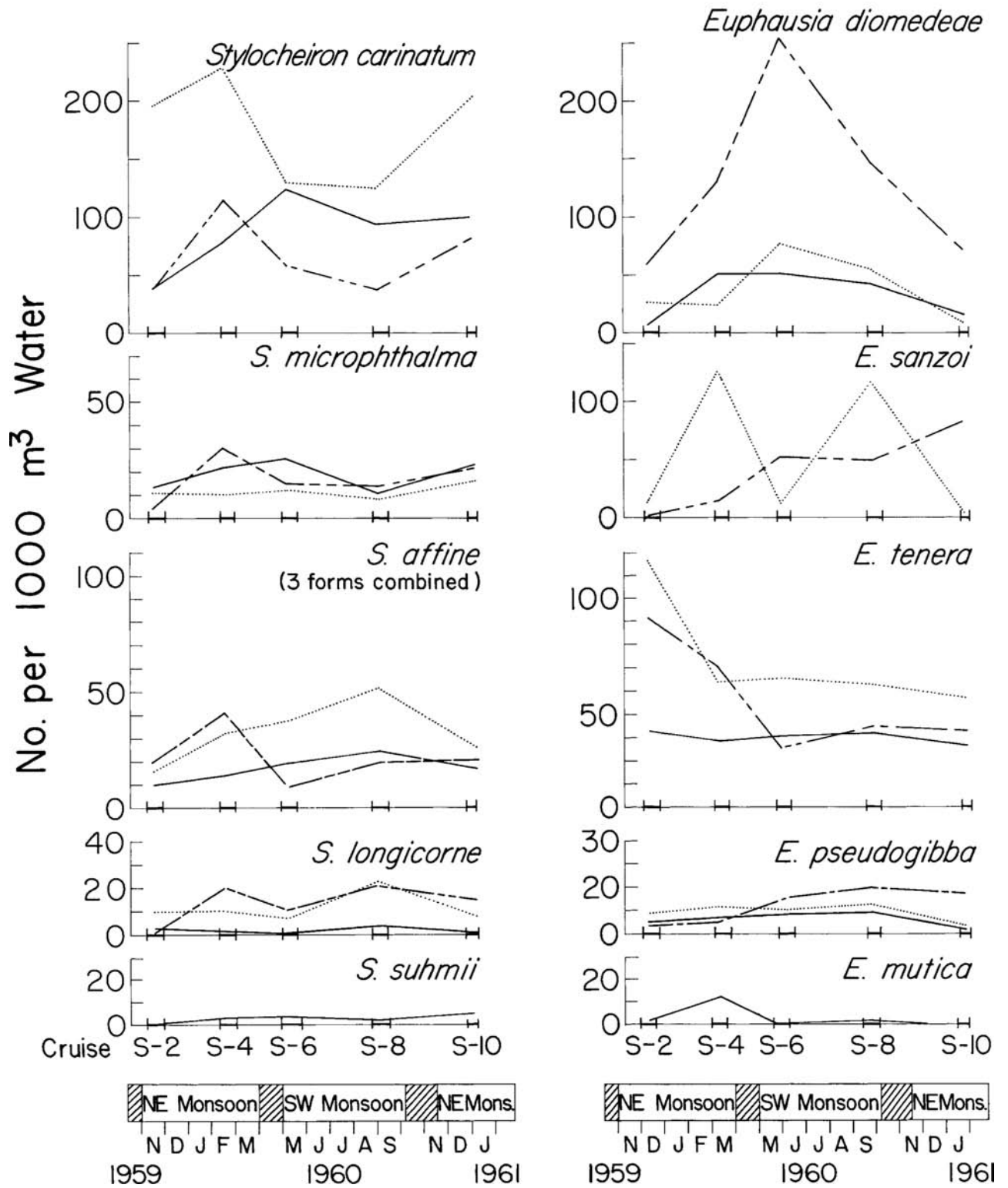
Figure 20. Abundances (mean of values at all stations at which species was present in South China Sea) of *Stylocheiron* and *Euphausia* species (larvae, juveniles and adults) by cruise.

September (Fig. 20) corresponded to the season of warmest temperatures at the favorable sites for *S. carinatum* larvae, S-6, S-8 (Table 2). Most of the less abundant species showed this general relationship. The converse was true in the case of *Euphausia diomedeae*. Maximum recruitment took place during S-6 and S-8, the warmest period (Table 2), and minimal recruitment during the coolest, S-10. *Thysanopoda tricuspidata* was found to be productive at both cool and warm localities during both the cooler and warmer seasons.

The range of salinity in the surface layer inhabited by these euphausiid larvae was much less in the basin than in the more coastal, sometimes estuarine waters occupied by *P. latifrons*. It ranged from a minimum of 32.7 ‰ (on cruises S-2 and S-8) to a maximum of 34 ‰ (on cruises S-4, S-6, S-8). No attempt was therefore made to consider salinity as a factor related to the distribution and abundance of larvae.

Table 2

TEMPERATURE (10 m) RELATIONSHIPS OF LARVAE OF CERTAIN OCEANIC SOUTH CHINA SEA SPECIES AT FAVORABLE SITES (STATIONS WITH >25 LARVAE PER 1000 m³)

| Species | Cruise | No. Stas. | At Favorable Sites | | | Temp. Range All. Stas. |
			Temp. Mean	Temp. at Peak No. Larvae	Temp. Range	
Stylocheiron carinatum	S-2	6	27.3	27.5	26.5-28.2	26.3-28.2
	S-4	21	26.8	26.8	24.1-27.6	22.2-28.0
	S-6	21	28.6	28.7	26.8-30.3	26.6-30.5
	S-8	20	28.7	28.5	28.1-29.9	28.1-29.9
	S-10	14	25.0	24.4	23.6-25.5	21.0-25.5
Euphausia diomedeae	S-2	7	27.4	27.5	26.5-28.2	"
	S-4	18	26.7	27.1	23.1-27.4	
	S-6	17	28.7	28.4	26.7-30.4	
	S-8	13	28.9	28.7	28.1-29.9	
	S-10	10	24.5	25.4	21.5-25.5	
Thysanopoda tricuspidata	S-2	9	27.1	27.0	26.6-27.6	"
	S-4	10	26.6	26.4	23.1-27.6	
	S-6	9	29.4	29.2	28.1-30.4	
	S-8	7	28.8	28.9	28.1-29.3	
	S-10	7	25.5	23.7	23.2-25.5	
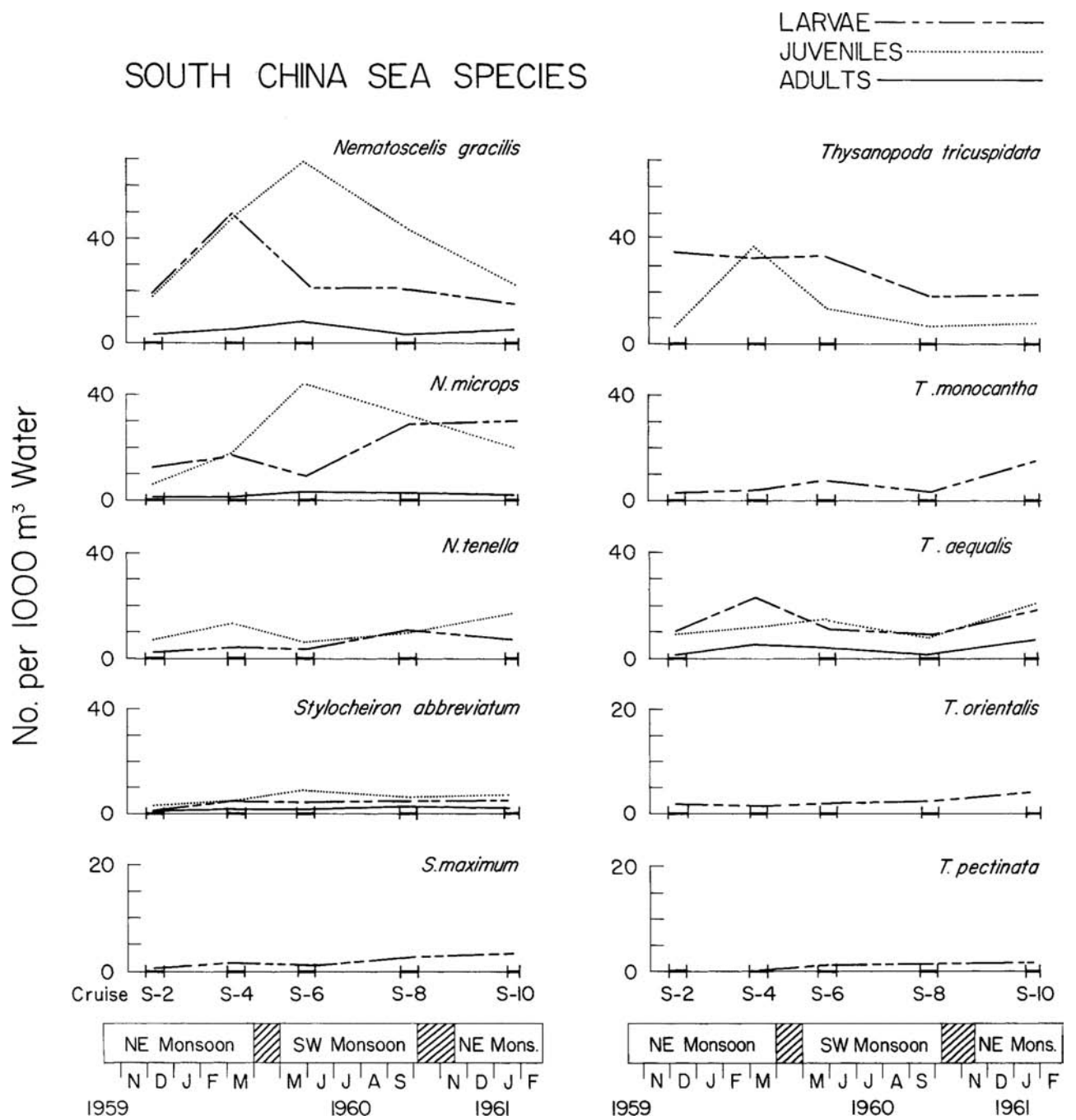
Figure 21. Abundances (mean of values at all stations at which species was present in South China Sea) of *Nematoscelis, Thysanopoda*, and *Stylocheiron* species (larvae, juveniles and adults) by cruise.
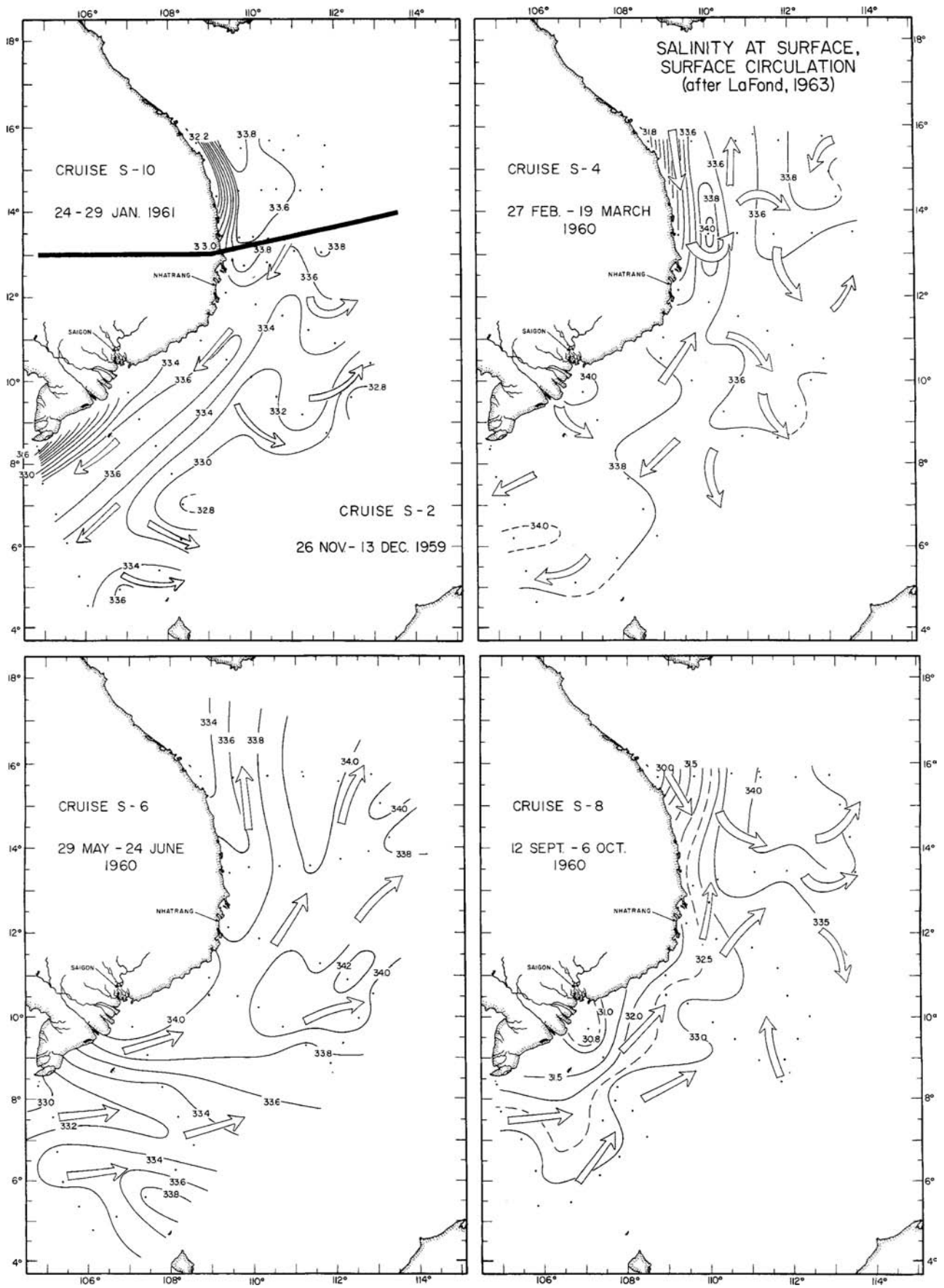
Figure 22. Salinity distribution and circulation at the surface. South China Sea cruises (after La Fond, 1963).
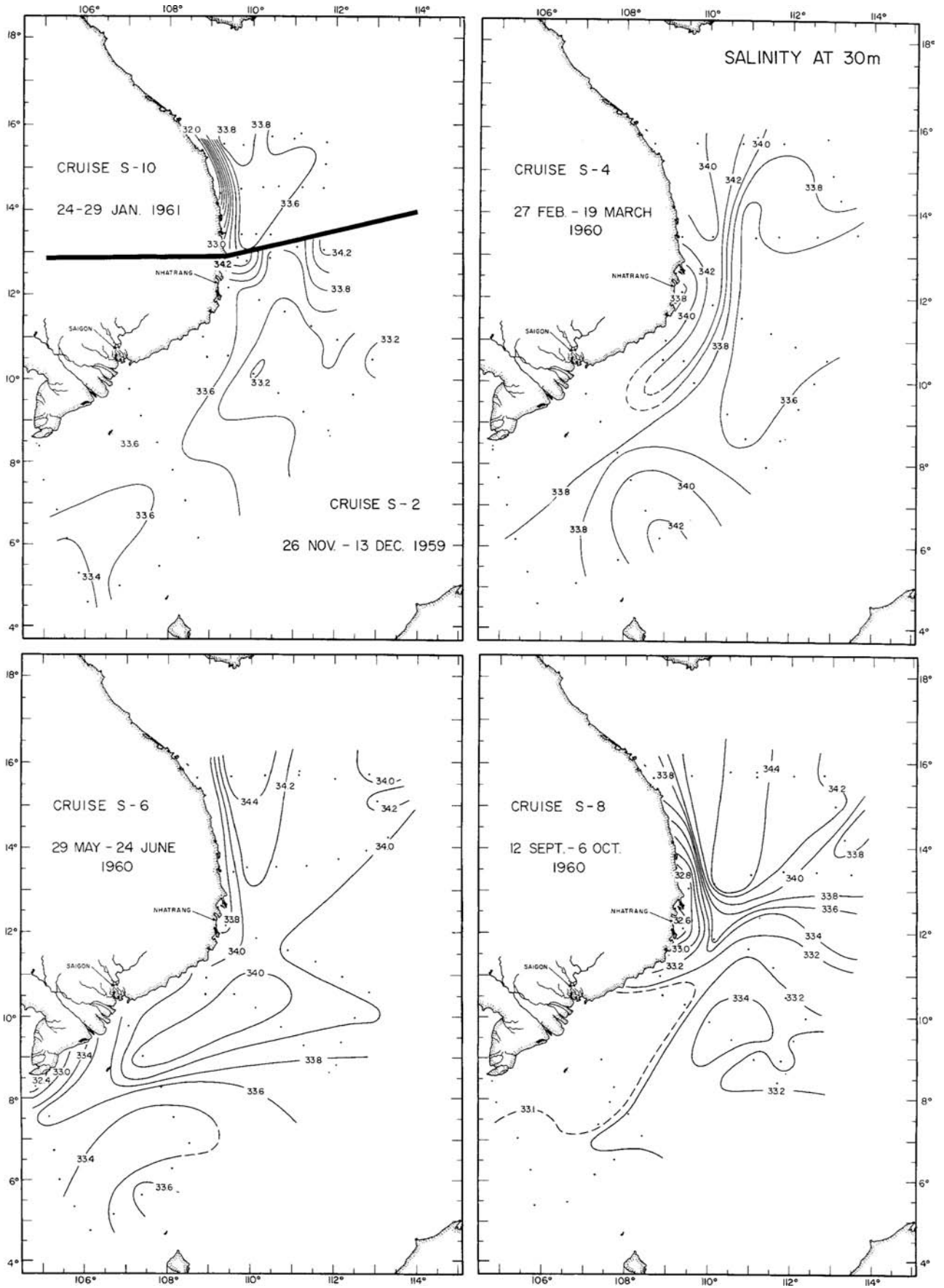
Figure 23. Salinity distribution at 30 m depth, South China Sea cruises.
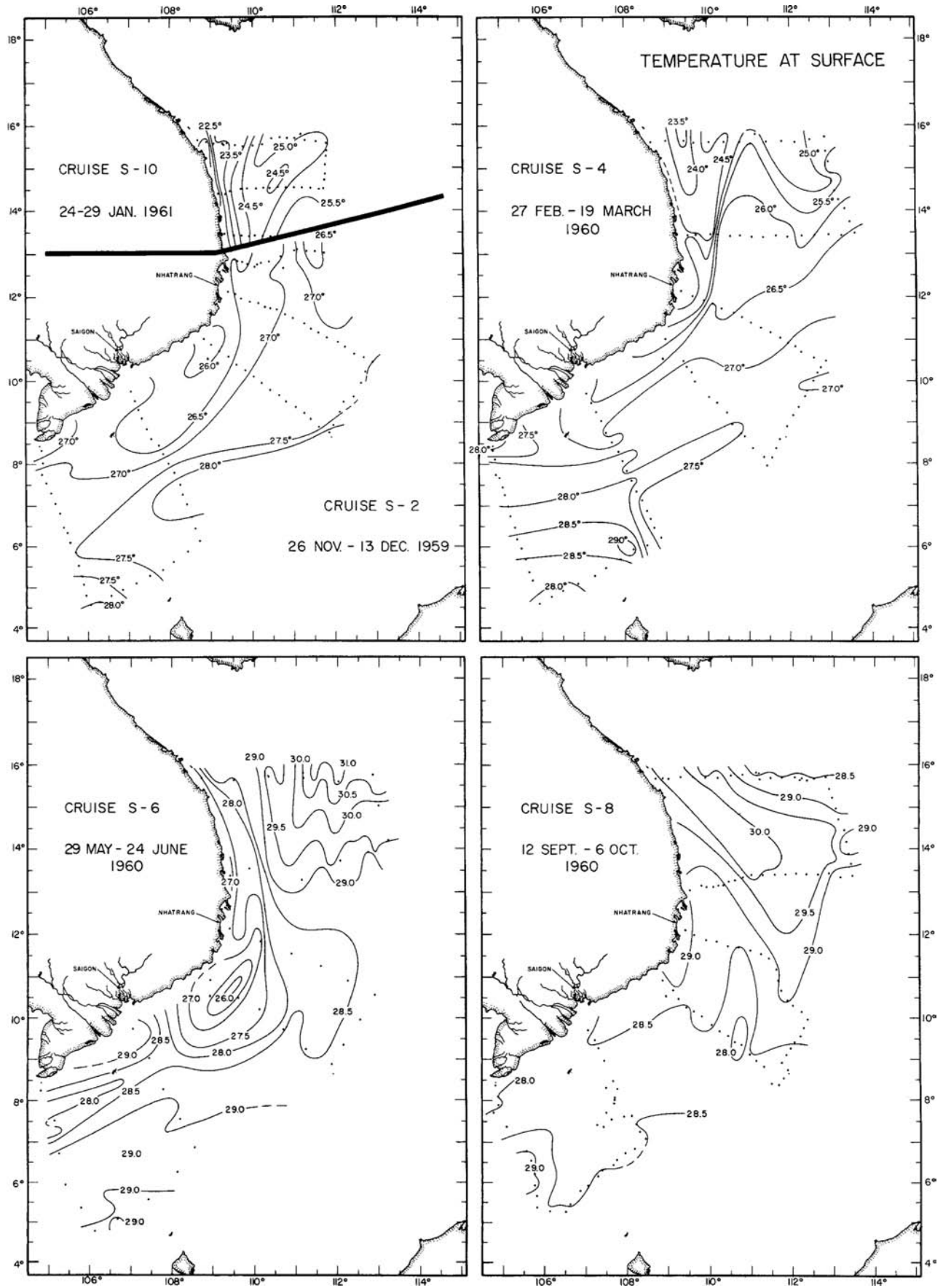
Figure 24. Temperature distribution at surface, South China Sea cruises.
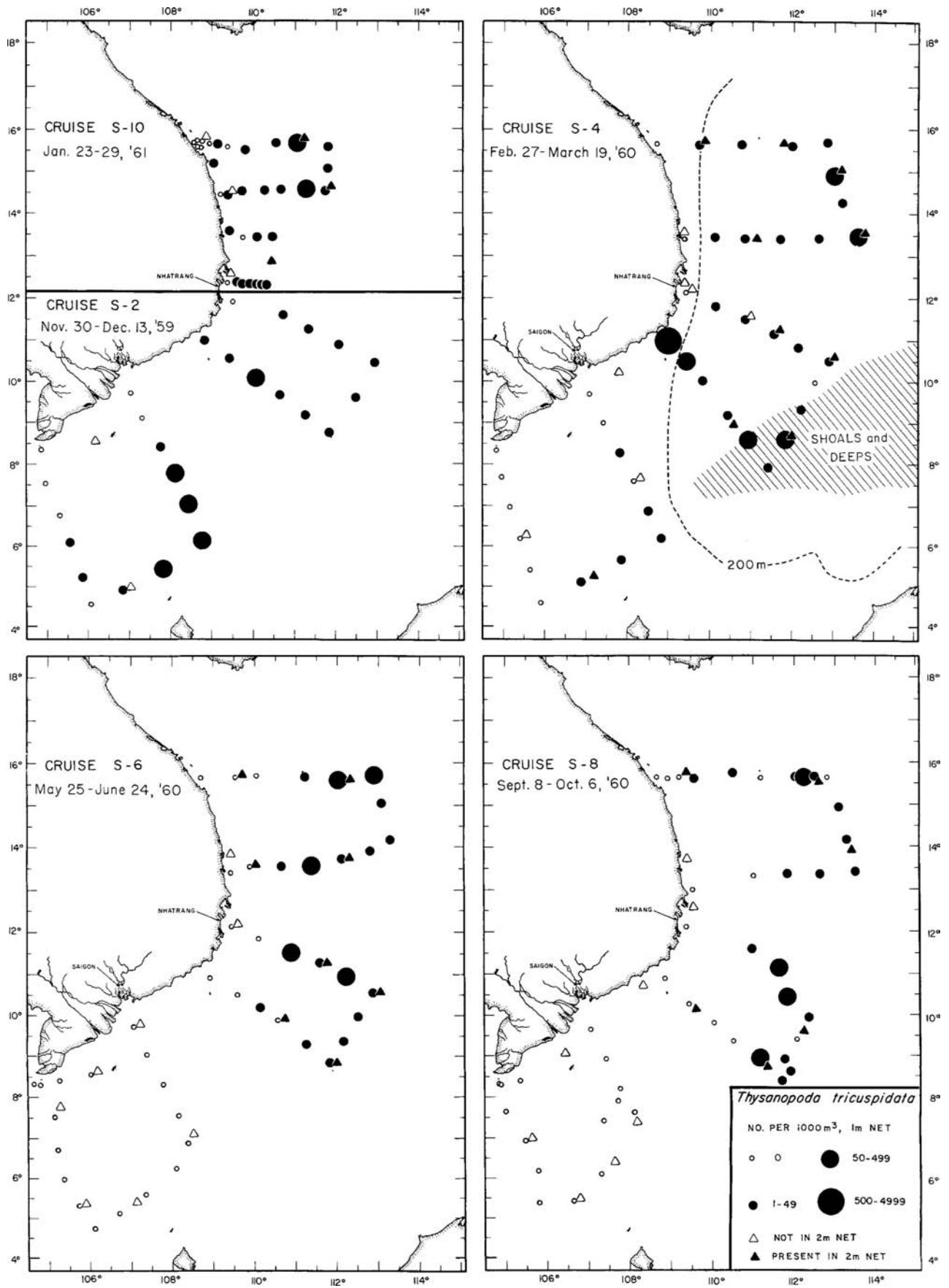
Figure 25. *Thysanopoda tricuspidata*, all sizes, South China Sea distributions.
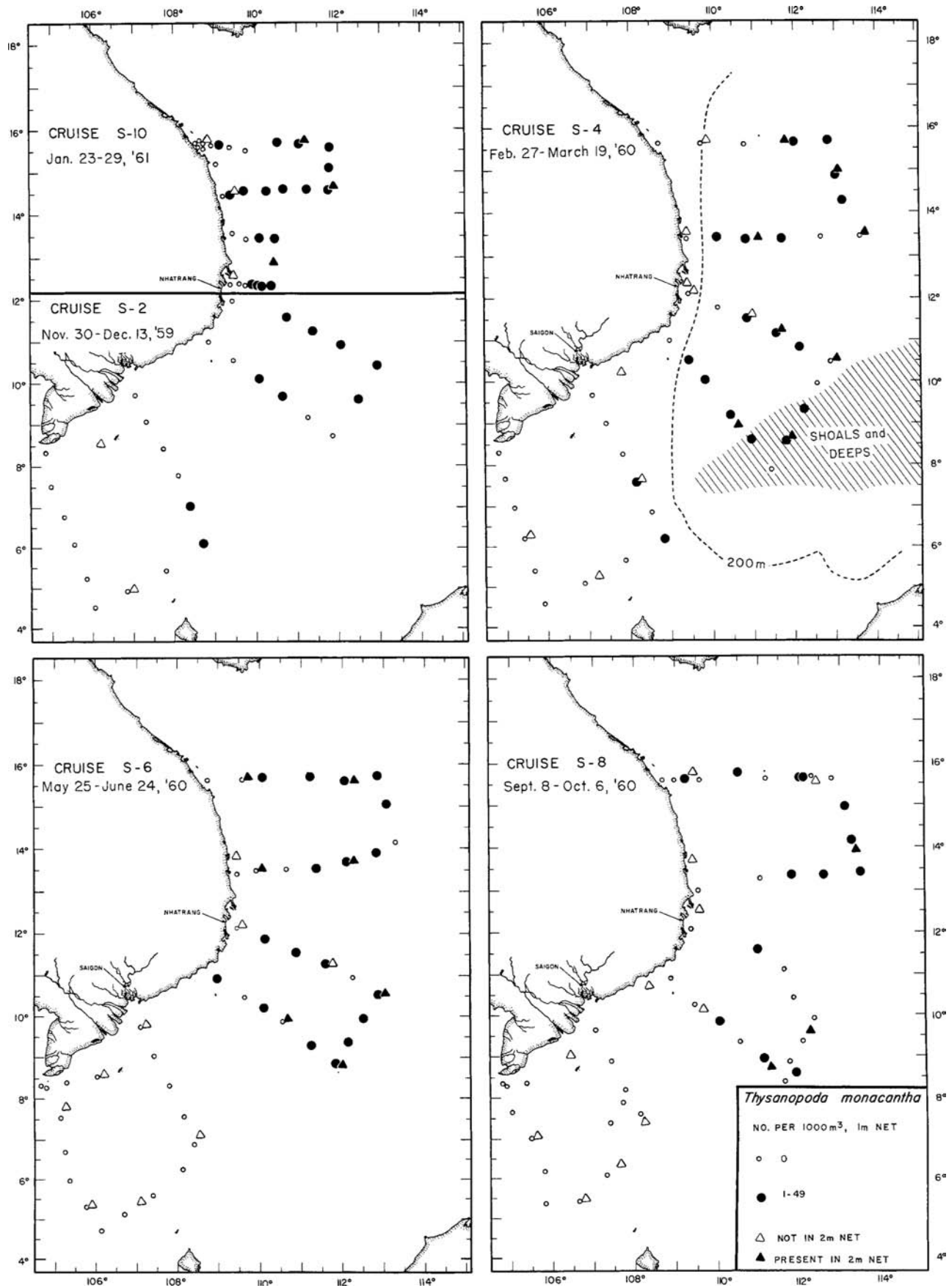
Figure 26. *Thysanopoda monacantha*, all sizes, South China Sea distributions.
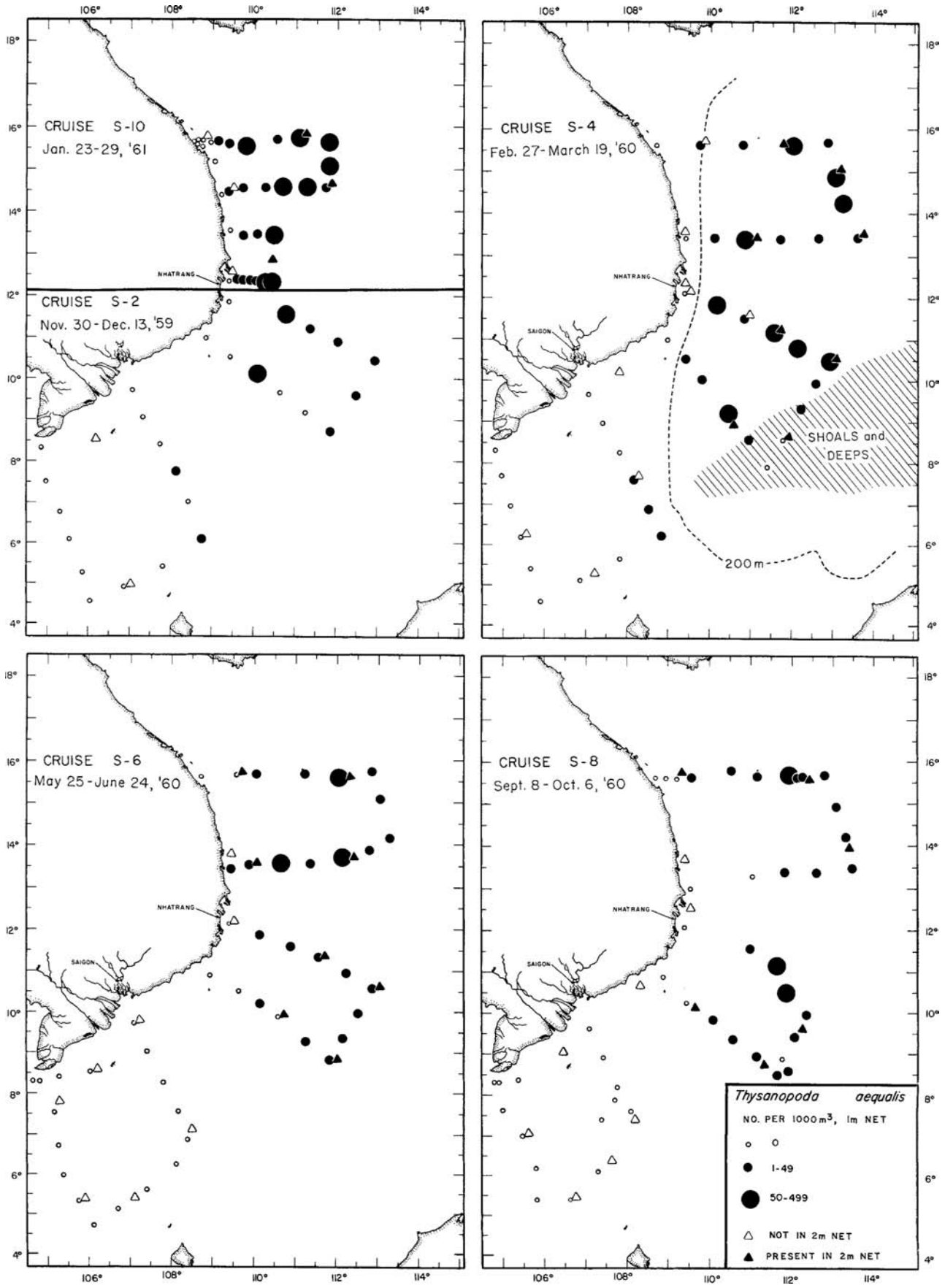
Figure 27. *Thysanopoda aequalis*, all sizes, South China Sea distributions.
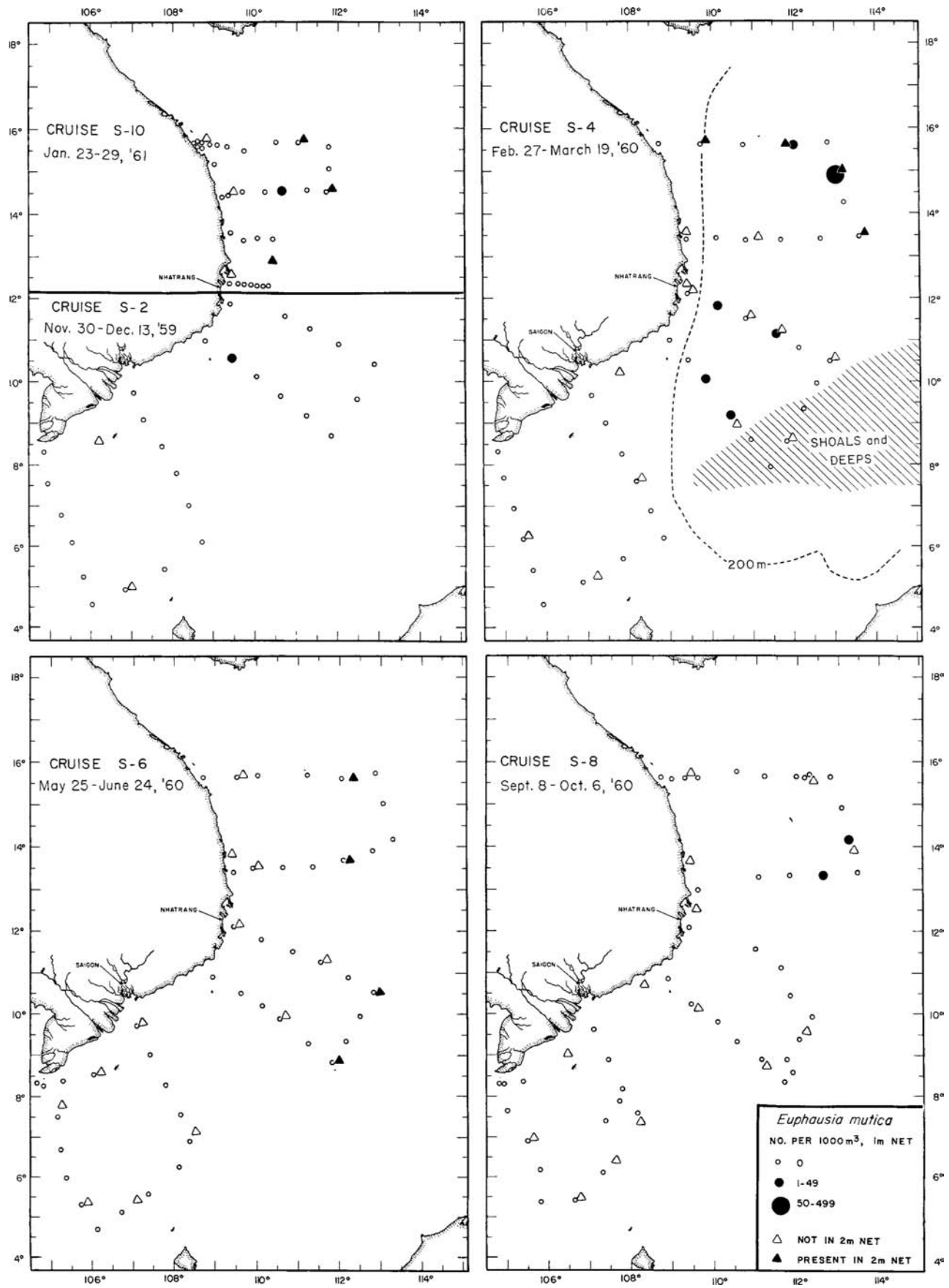
Figure 28. *Euphausia mutica*, all sizes, South China Sea distributions.
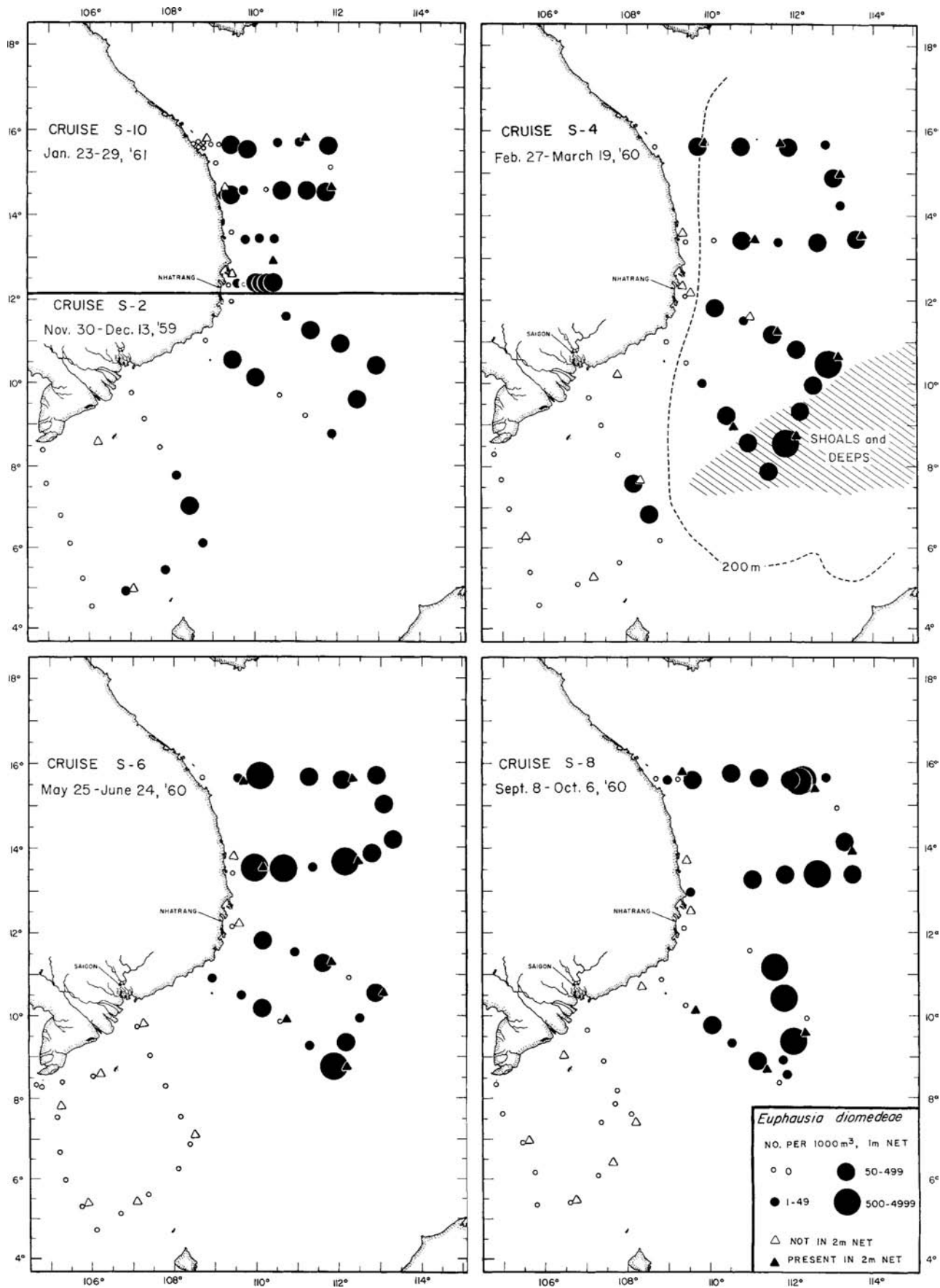
Figure 29. *Euphausia diomedeae*, all sizes, South China Sea distributions.
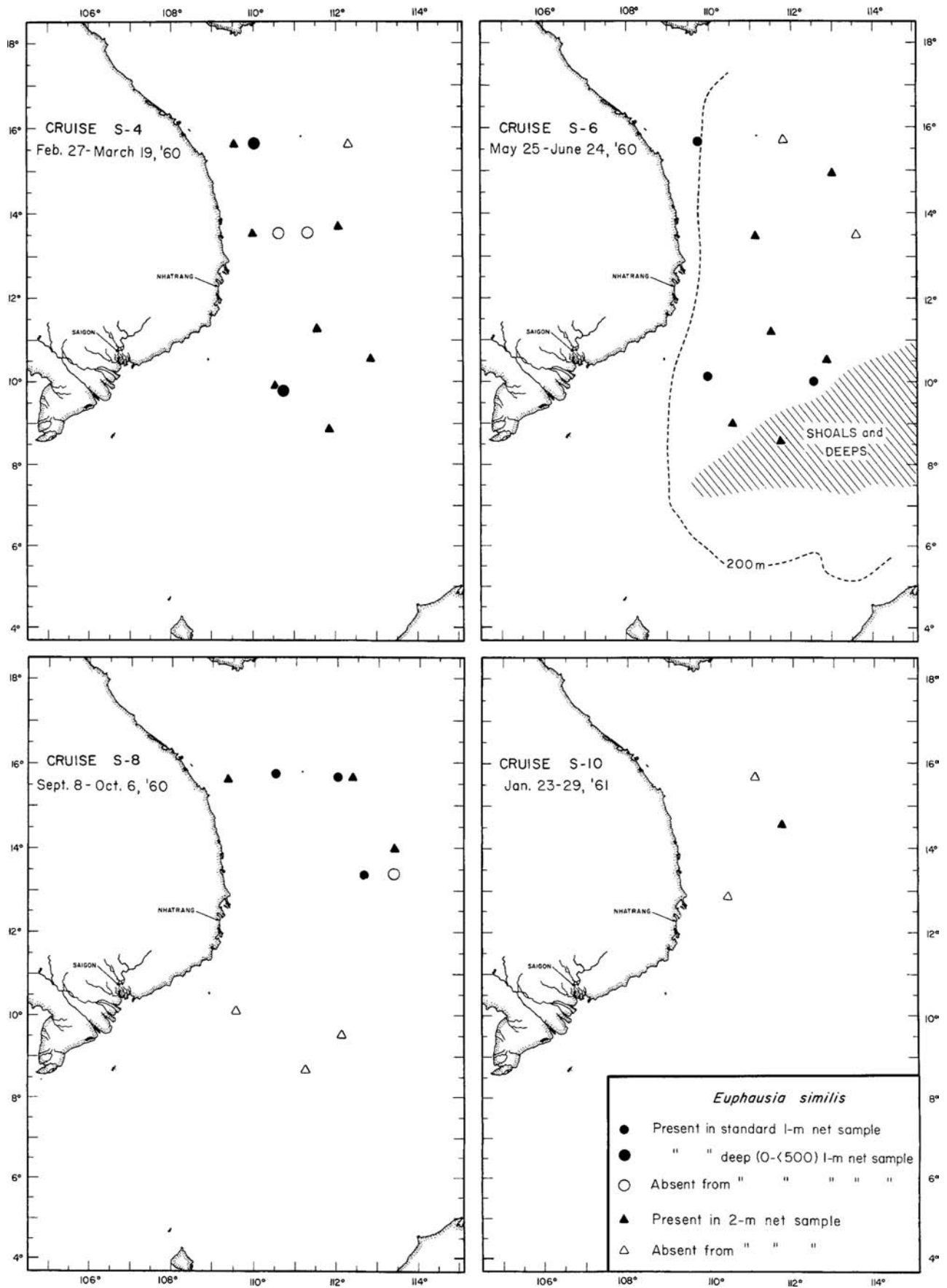
Figure 30. *Euphausia similis*, all sizes, South China Sea distributions.
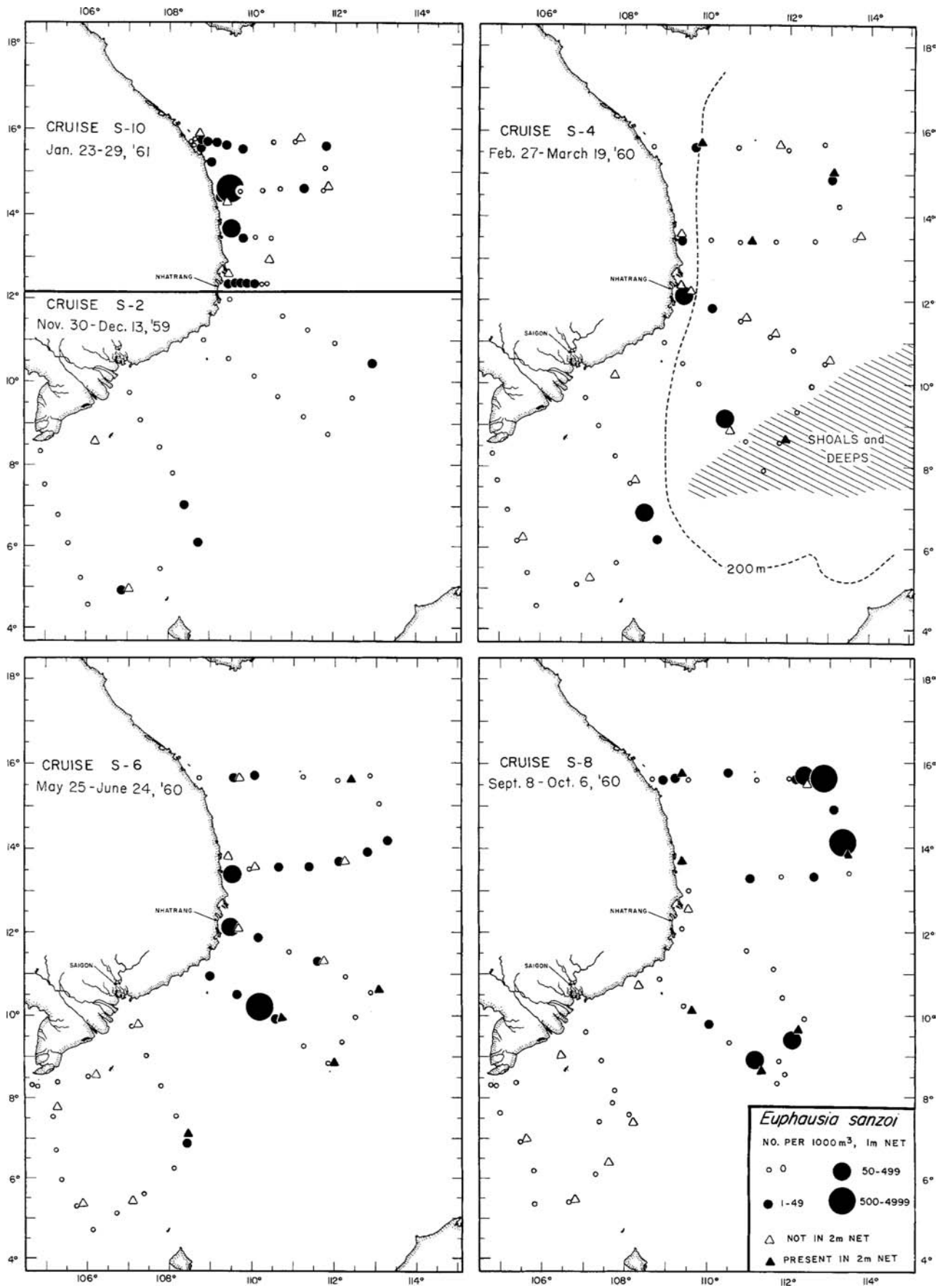
Figure 31. *Euphausia sanzoi*, all sizes, South China Sea distributions.
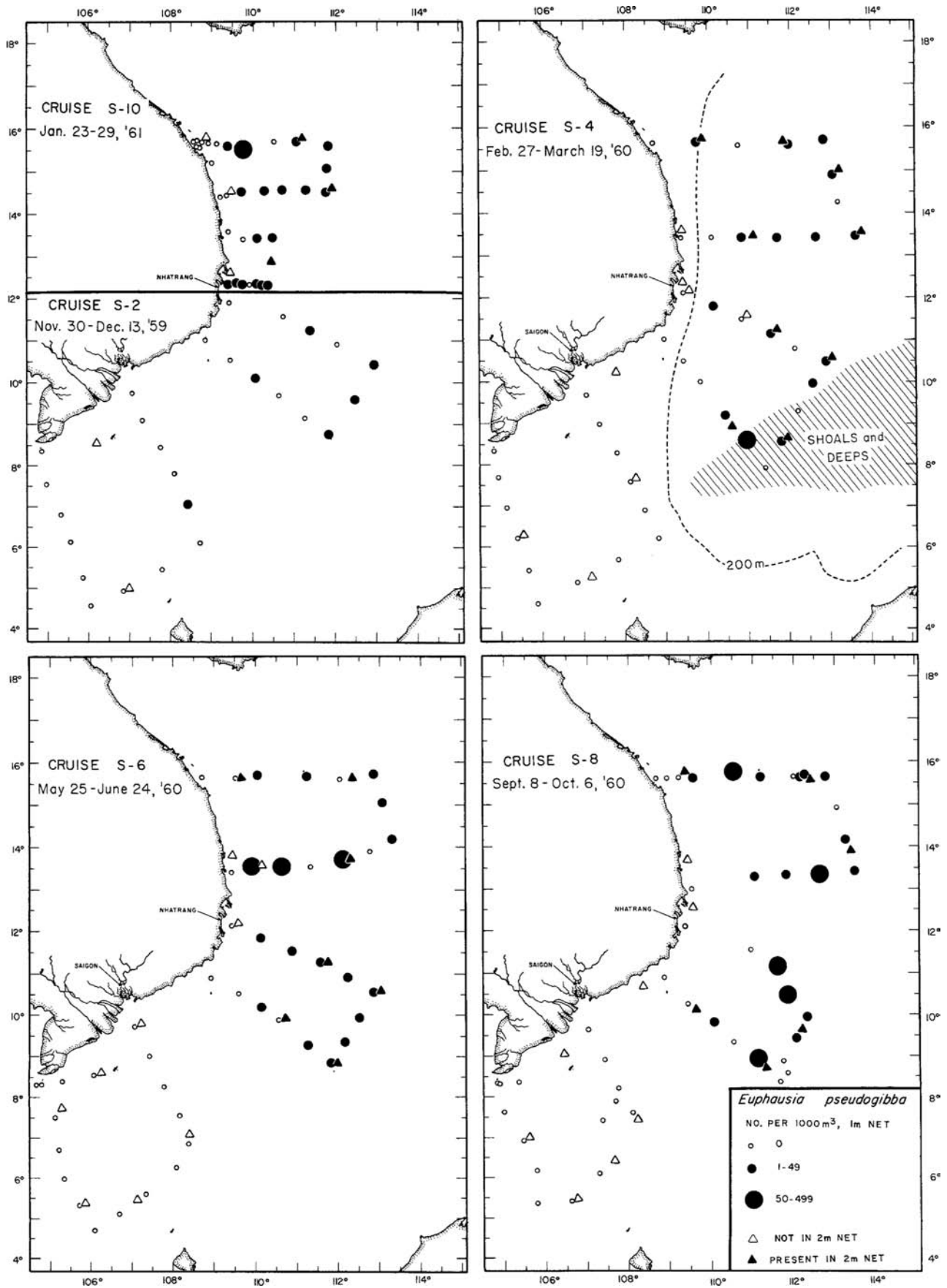
Figure 32. *Euphausia pseudogibba*, all sizes, South China Sea distributions.
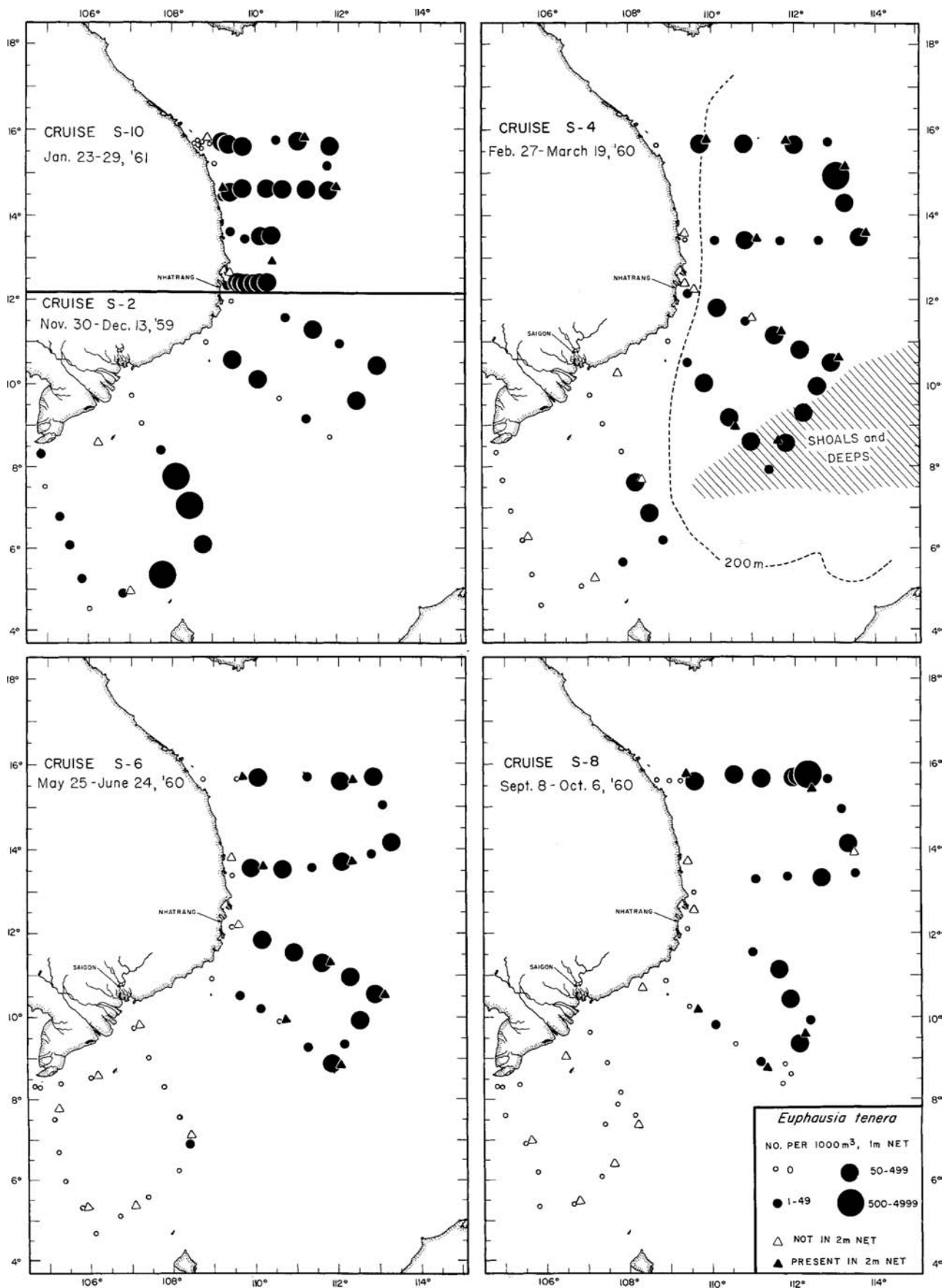
Figure 33. *Euphausia tenera*, all sizes, South China Sea distributions.
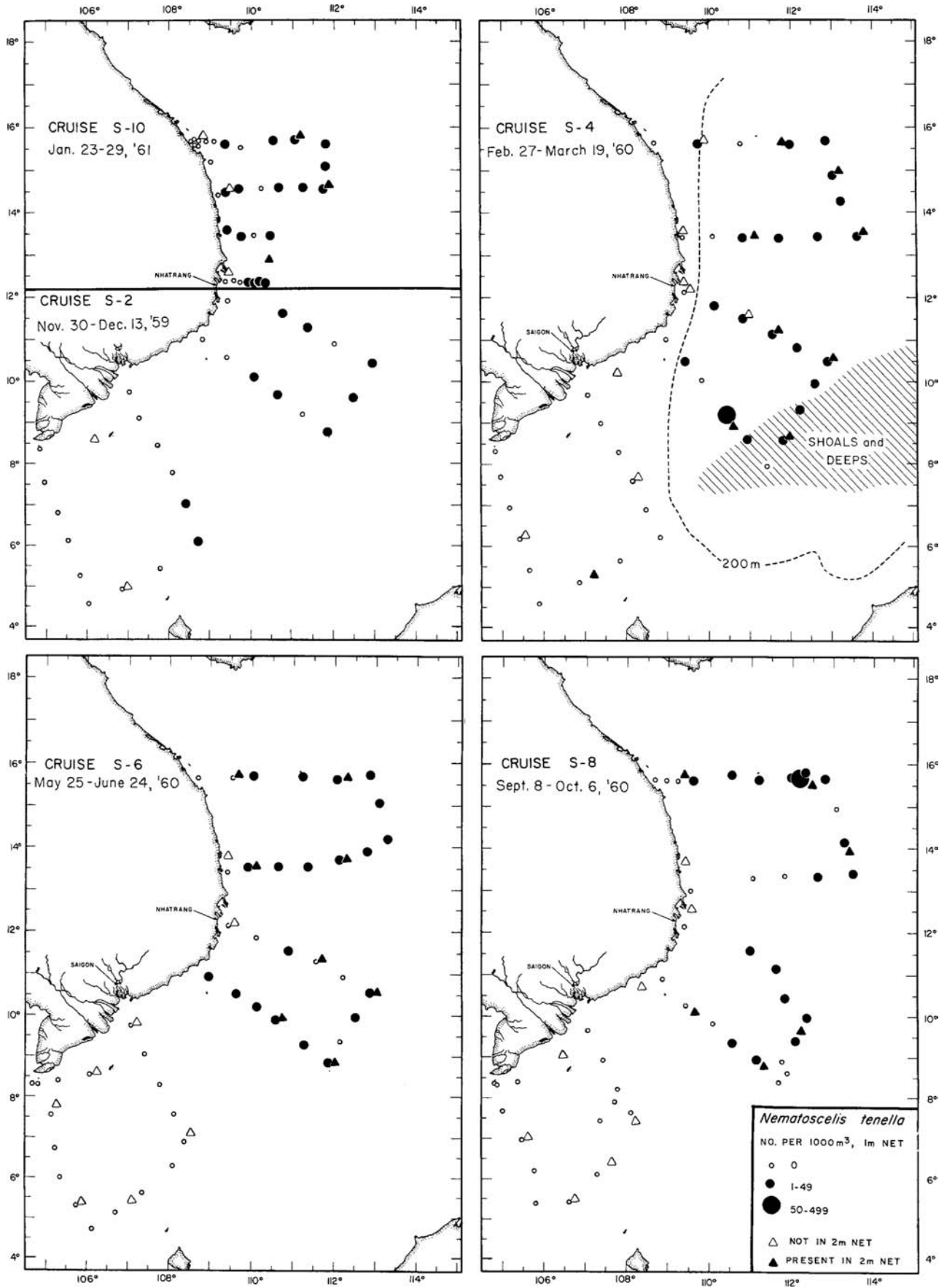
Figure 34. *Nematoscelis tenella*, all sizes, South China Sea distributions.
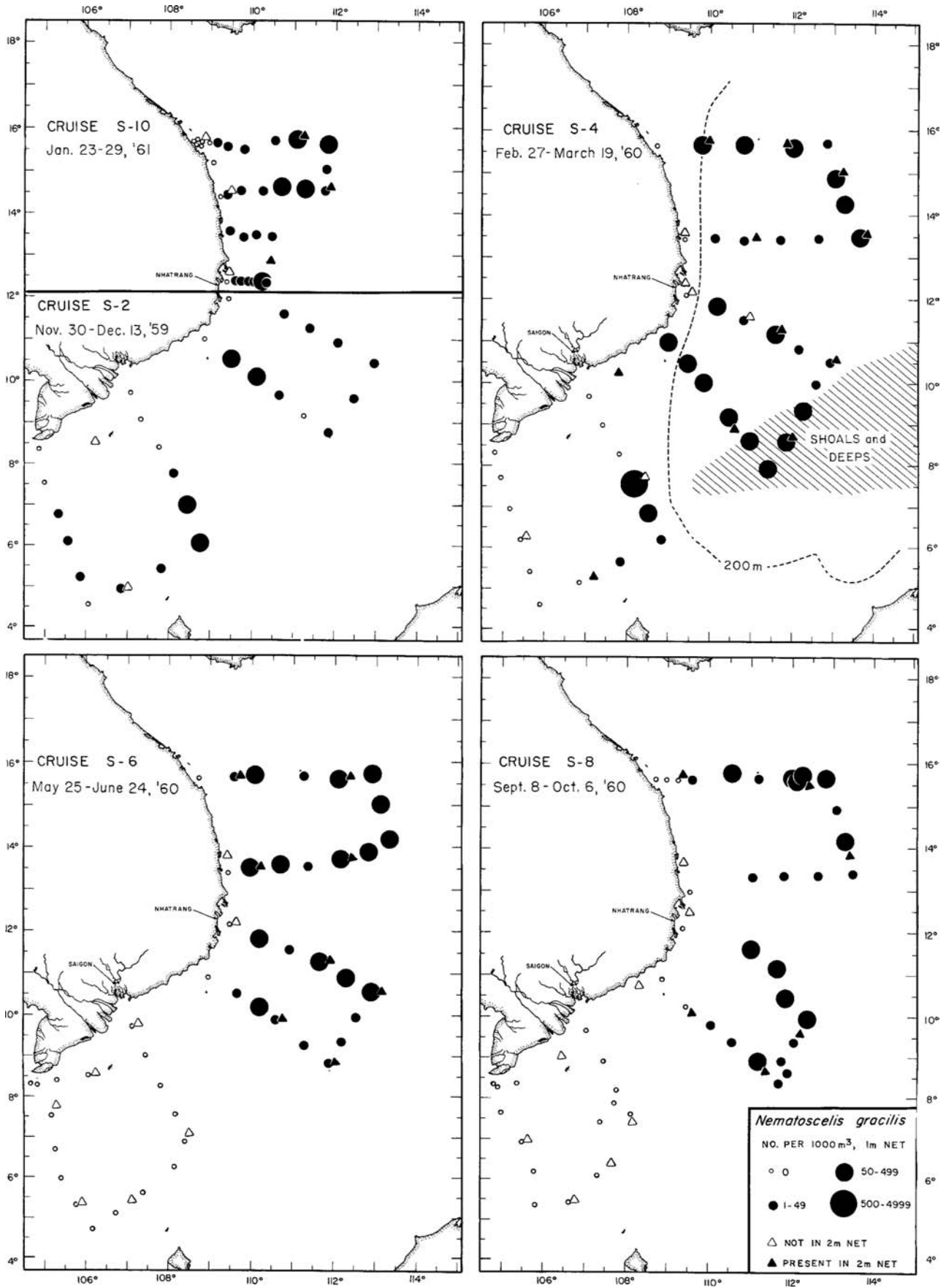
Figure 35. *Nematoscelis gracilis*, all sizes, South China Sea distributions.
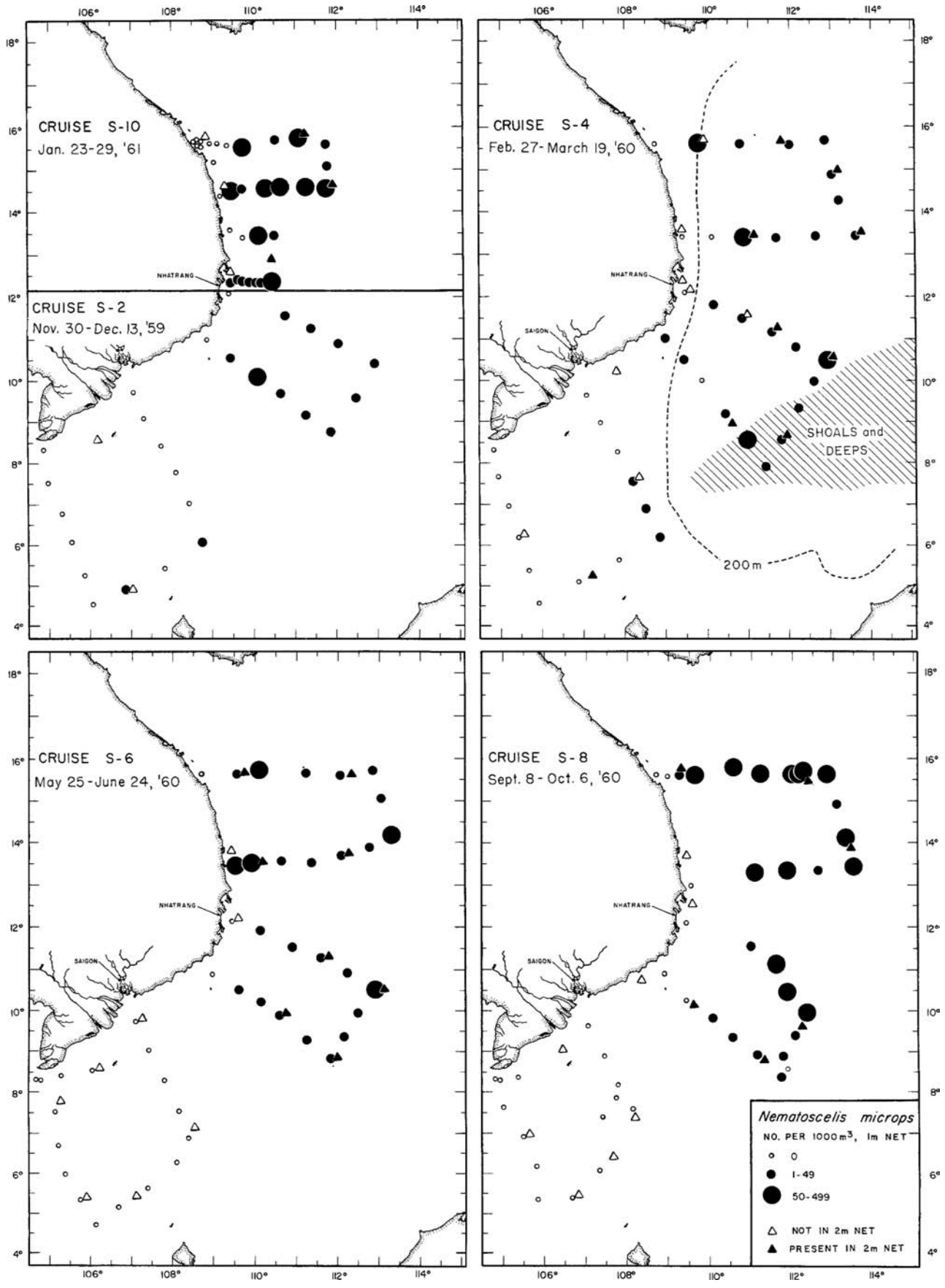
Figure 36. *Nematoscelis microps*, all sizes, South China Sea distributions.
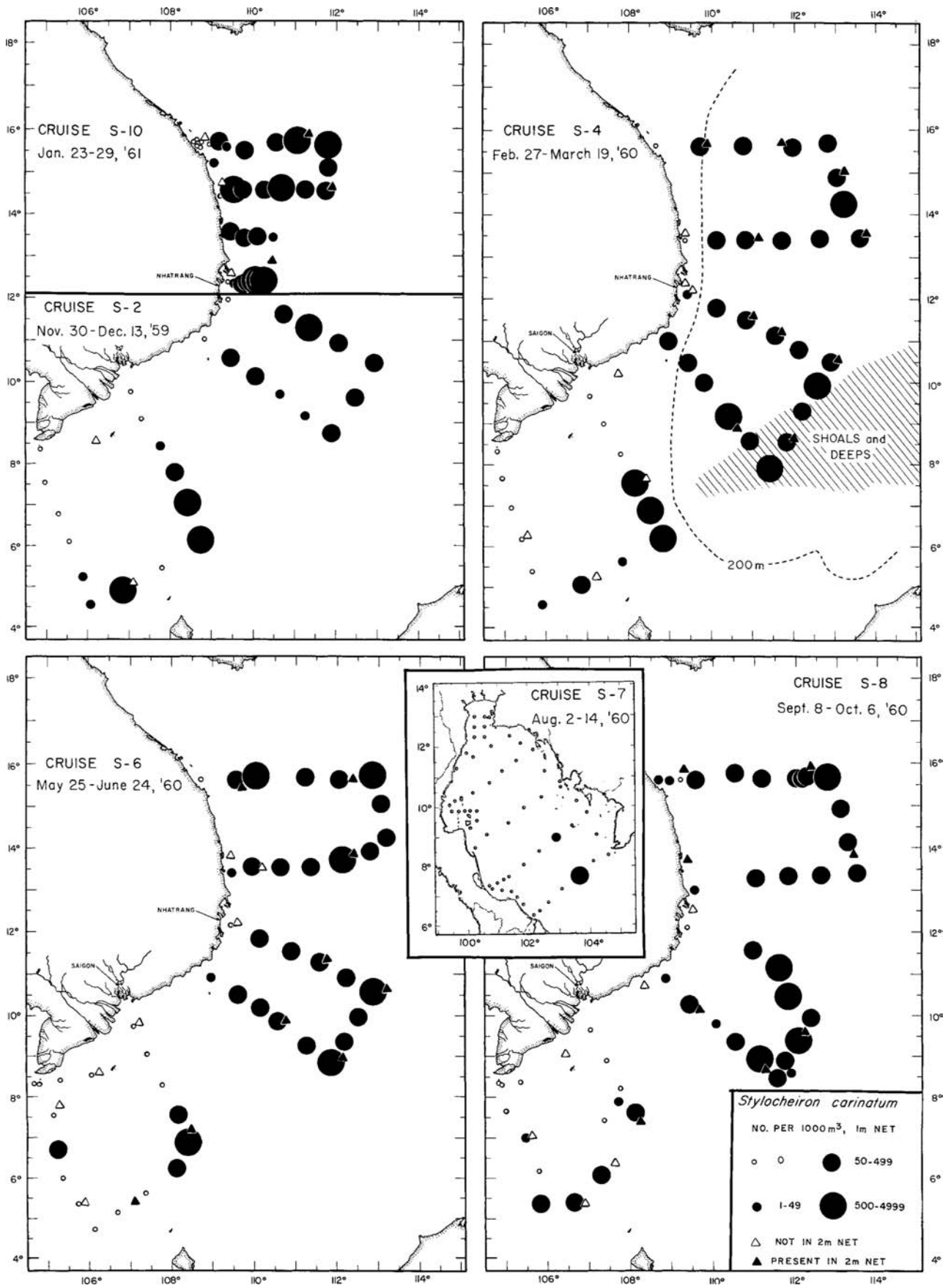
Figure 37. *Stylocheiron carinatum*, all sizes, South China Sea distributions.
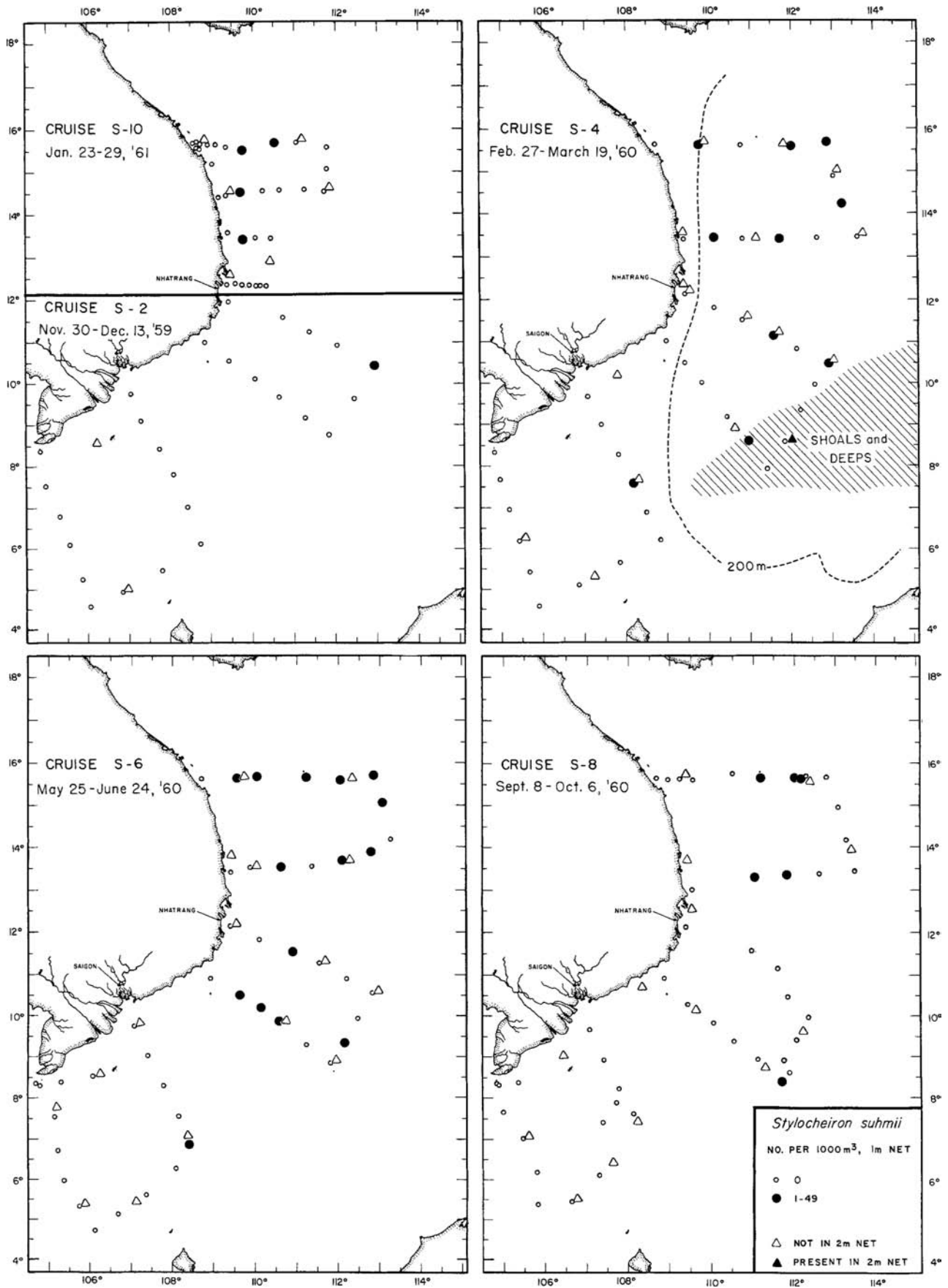
Figure 38. *Stylocheiron suhmii*, all sizes, South China Sea distributions.
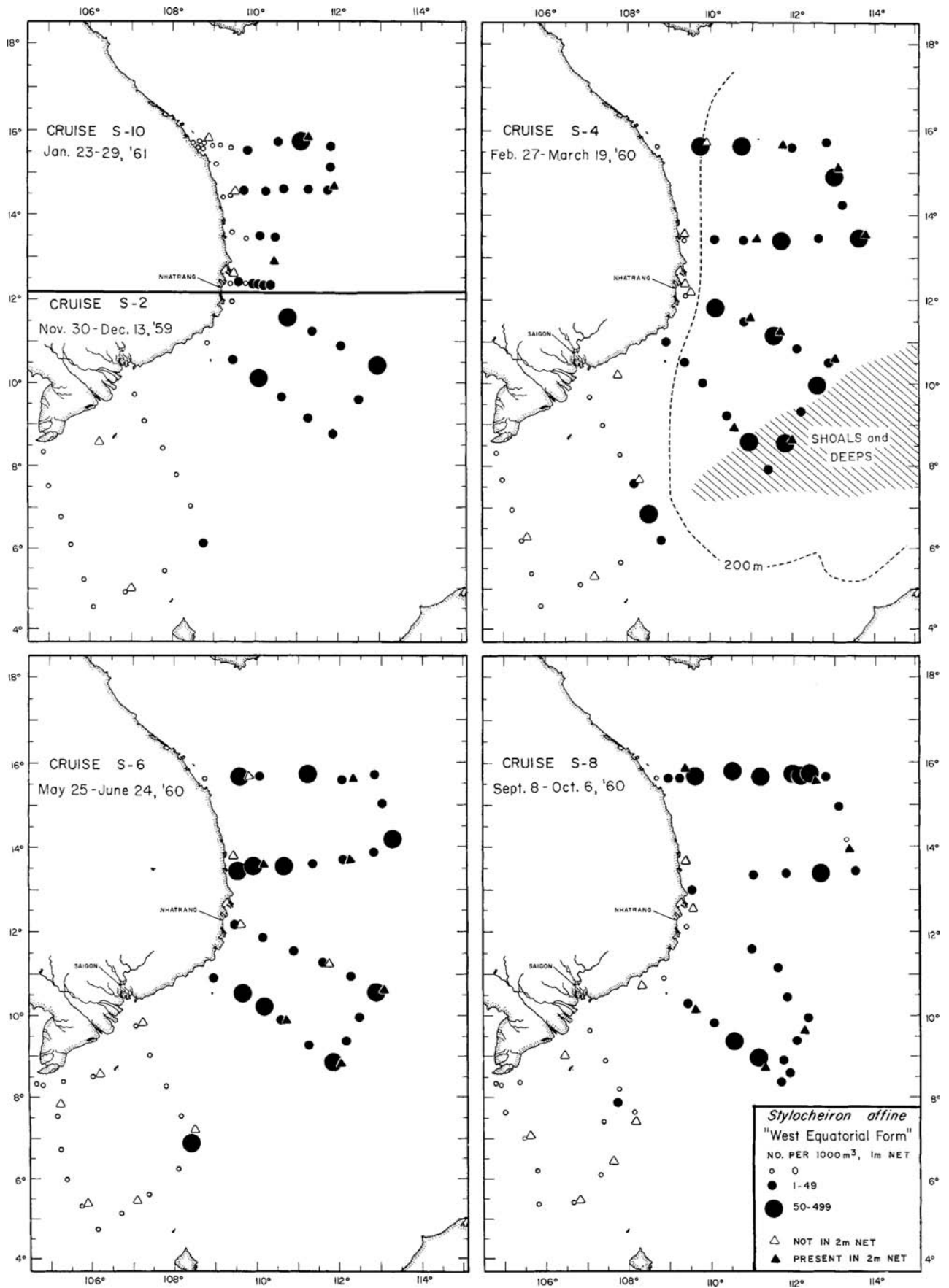
Figure 39. *Stylocheiron affine* West Equatorial Form, all sizes, South China Sea distributions.

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Figure 40. *Stylocheiron affine* Indo-Australian Form, all sizes, South China Sea distributions.

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Figure 41. *Stylocheiron affine* Central Form, all sizes, South China Sea distributions.

Figure 42. *Stylocheiron microphthalma*, all sizes, South China Sea distributions.

Figure 43. *Stylocheiron longicorne*, Long and Short Forms combined, all sizes, South China Sea distributions.

Figure 44. *Stylocheiron abbreviatum*, all sizes, South China Sea distributions.

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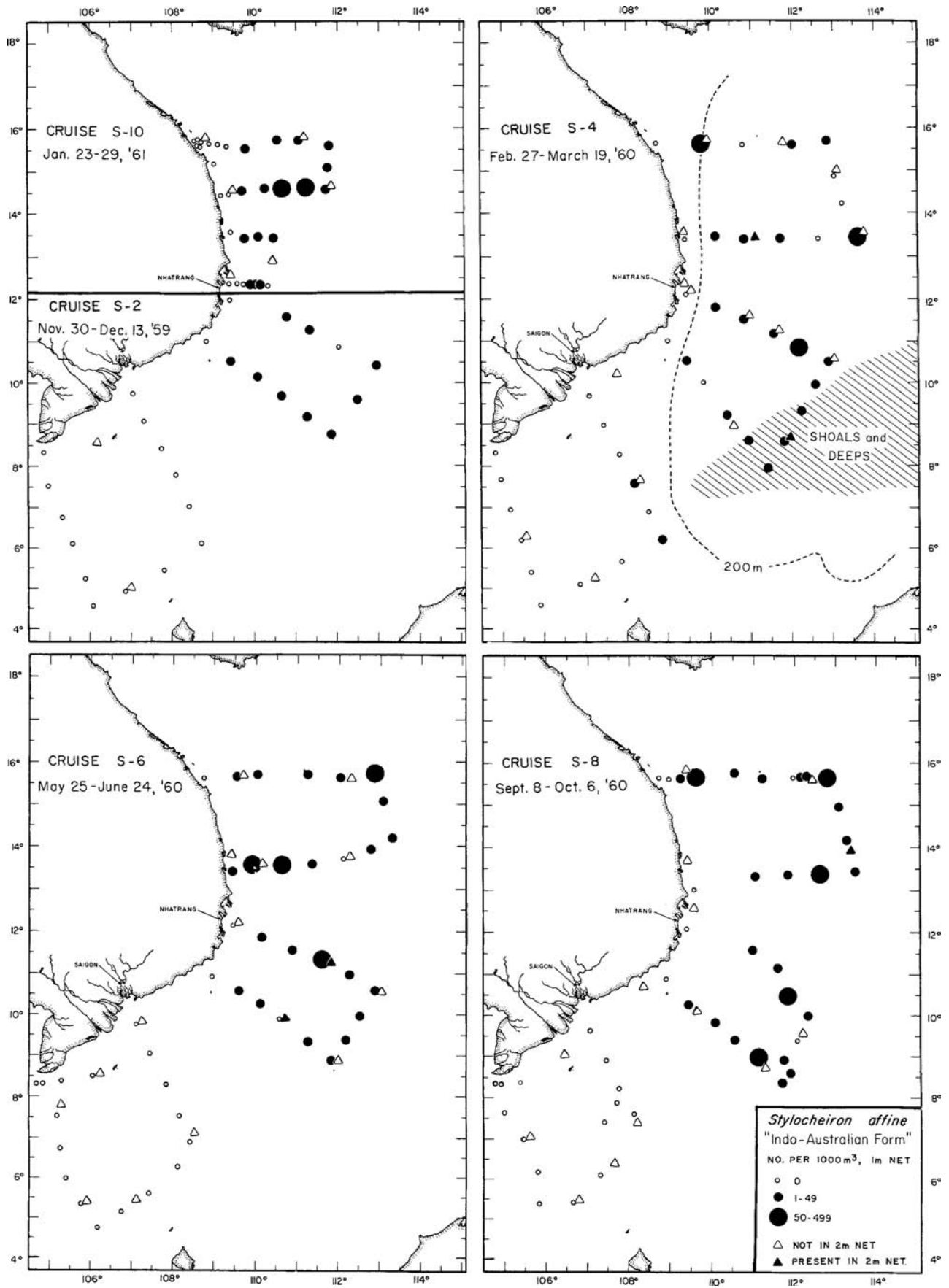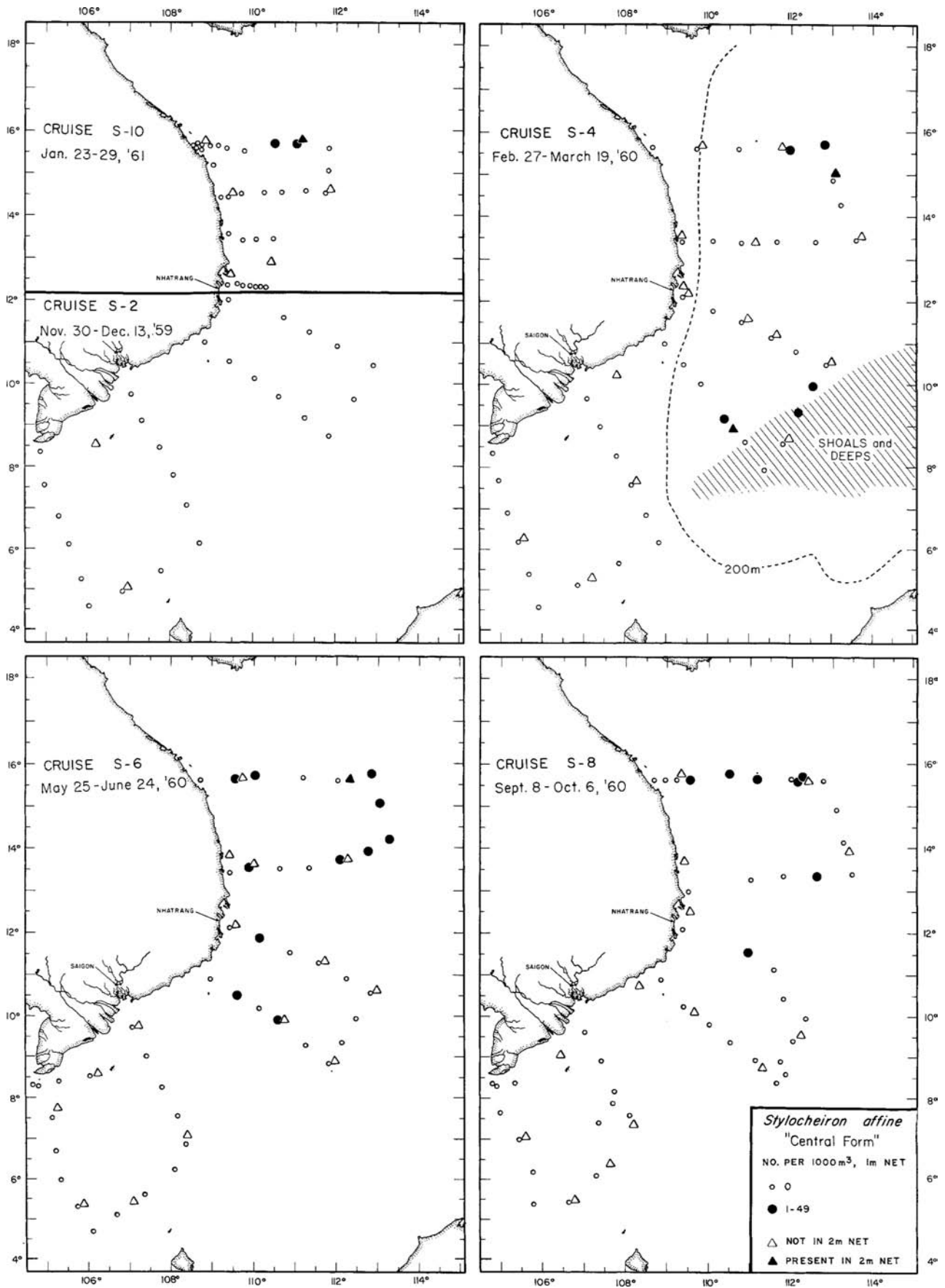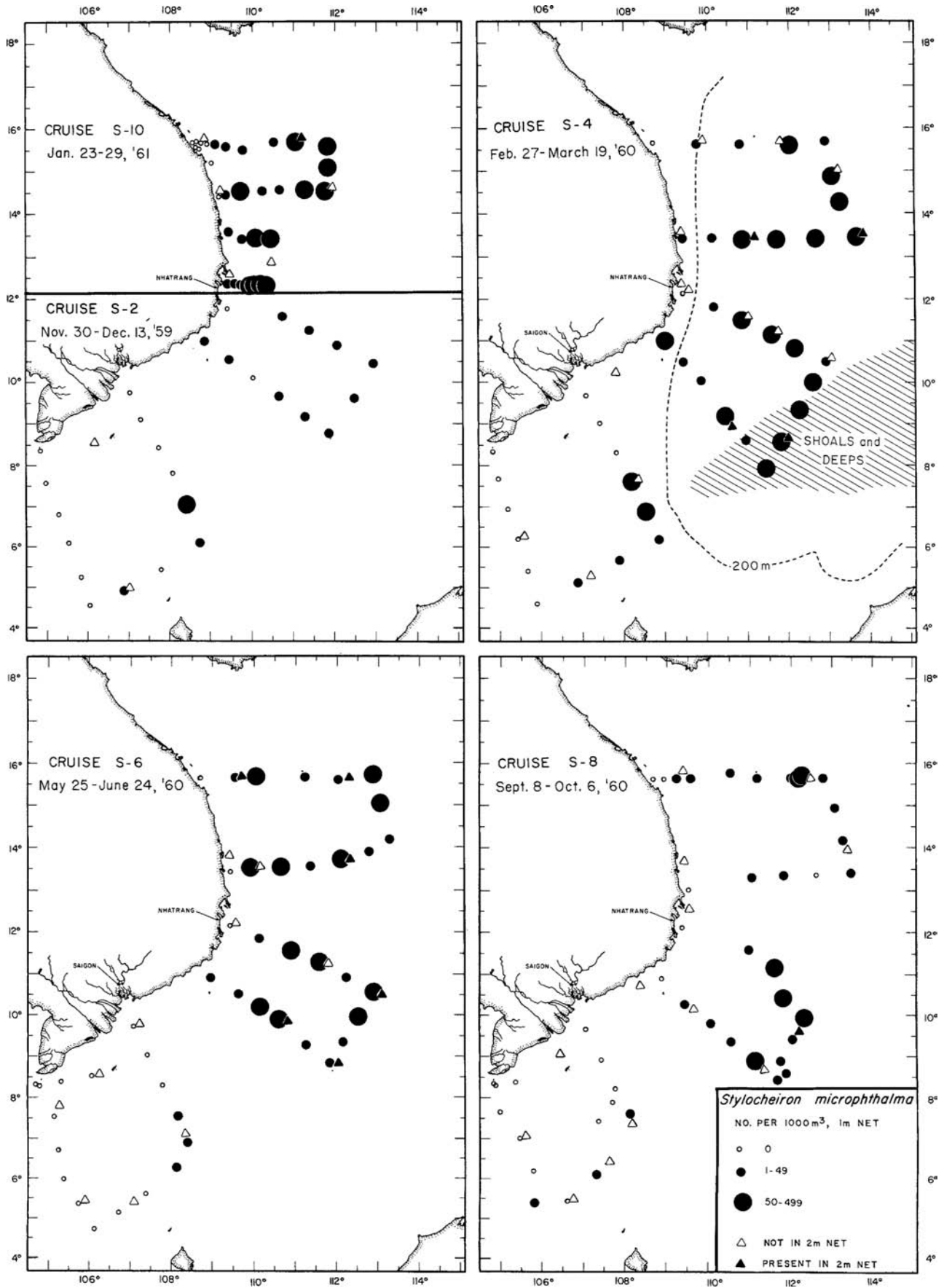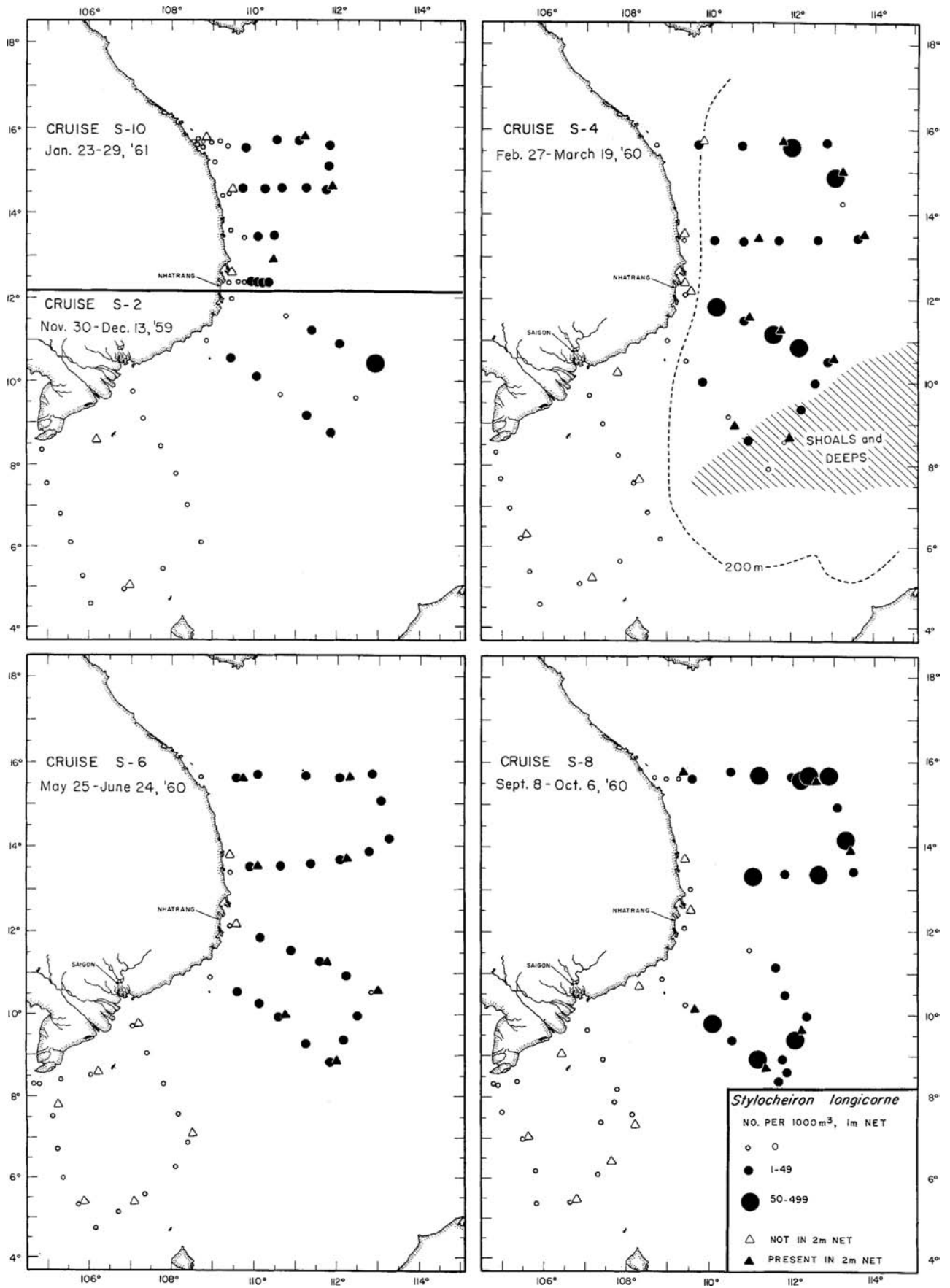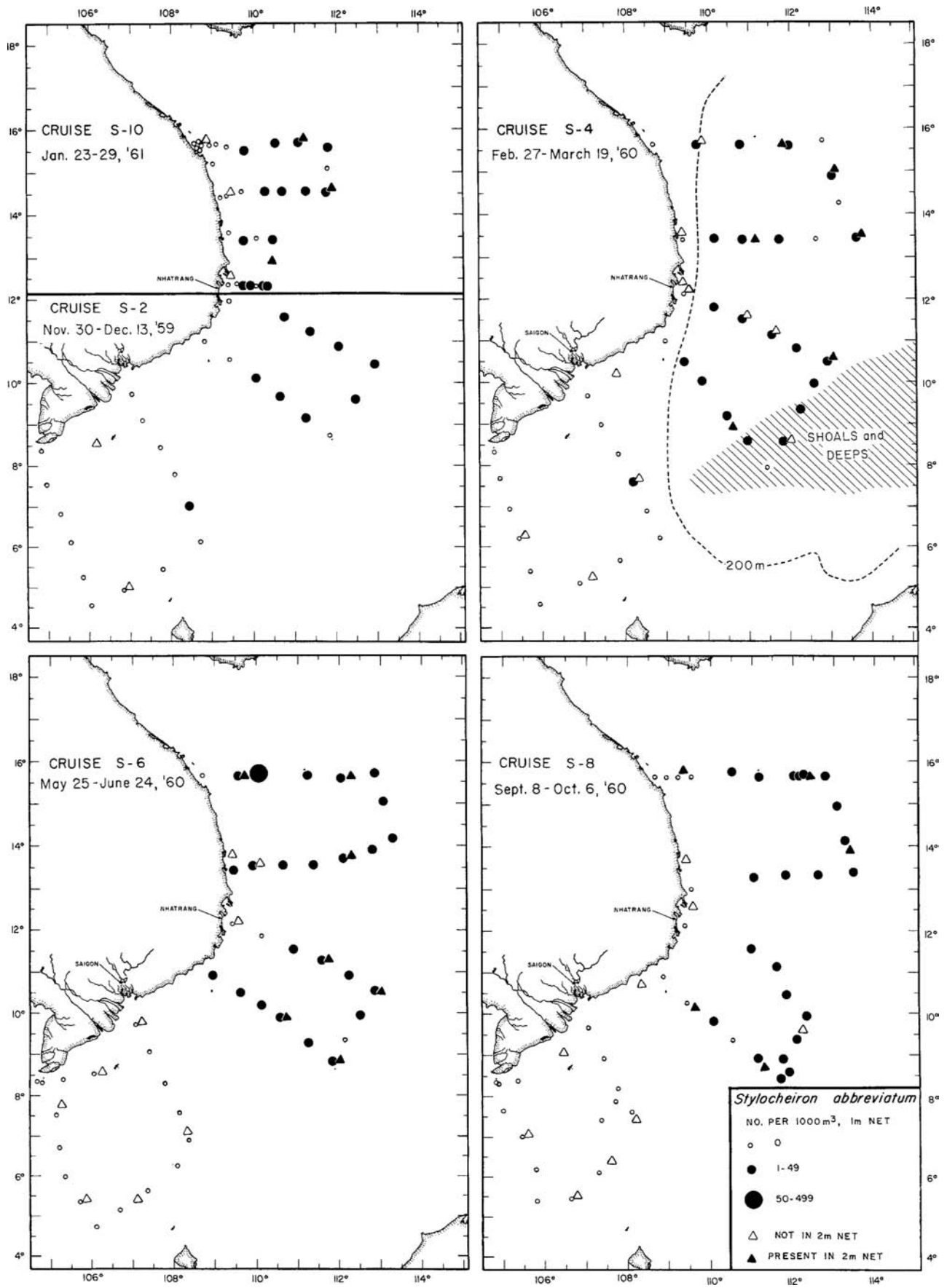# SECTION II. SPECIES DISTRIBUTION AND THE QUESTION OF INTER-OCEAN COMMUNICATION

PHYSICAL CHARACTERISTICS OF THE INTER-OCEAN CONNECTION

The southeast Asian seas discussed above are the most northern waters of the region connecting the Indian and Pacific Oceans. The Gulf of Thailand is a semi-autonomous branch of the extensive neritic environment which extends over the Sunda Shelf from 10° N on both sides of the Indo-Chinese peninsula southward to Java, 10° S. *Pseudeuphausia latifrons* was the only euphausiid species found in the Gulf, except for the occurrences of *Stylocheiron carinatum* during cruise S-7. Though mainly a neritic species, *P. latifrons* occurs throughout the inter-ocean connection.

The South China Sea's oceanic community consists largely of species characteristic of the western tropical Pacific (e.g., *Euphausia diomedeae, Nematoscelis gracilis*), but it has a regional identity in which *Euphausia pseudogibba* totally replaces *E. paragibba, Thysanopoda aequalis* is found instead of *T. astylata* and *Euphausia sanzoi* is generally important.

This assemblage is in continuity with the open Pacific through the Bashi Channel which separates Taiwan from the Philippines and through which the equatorial fauna of the Kuroshio intrudes. Dilution by central water mass plankton which originates to the northwest is a seasonal feature of the South China Sea. *Pseudeuphausia* appears to continuously diffuse across the basin from its centers along the neritic margins of the sea, particularly the shelf to the southeast. However, the oceanic species scarcely transgress those shallow margins and cannot utilize interocean waterways at the Straits of Malacca and the Sunda Strait. Thus, the Sunda Shelf serves as a barrier totally separating planktonic inhabitants of the South China Sea from those of the Indian Ocean.

On the other hand, a cluster of deep basins connects the two oceans to the east of Borneo and Java and to the west of New Guinea and the Arafura Sea. In looking at the inter-ocean seas as agents in the speciation process, hydrographic characteristics of the region must be examined together with the biogeographic, even though mechanisms of population isolation or intercommunication cannot be fully understood in available hydrographic terms. The direction of water transport at least determines where physical pressure for range extension or contraction is being applied.

Flow in the homogeneous layer provides surface continuity throughout the area. The Sunda Shelf is traversed by superficial flow (above 50-100 m depth and reversing with season, Fig. 1a, b). Between basins, deeper exchange also takes place in most cases. Sills separating basins of the Molucca, Celebes, Banda, Flores, Timor and Sawu Seas complex are deeper than 1000 m. Even the Sulu and South China Seas communicate, though narrowly, near the Philippines, over a sill at 450 m depth; however, these two basins are both significantly isolated from the rest of the Austral-Asian region with respect to their circulation beneath the thin homogeneous layer.

Thus, the extent of separateness of these several seas might appear more relevant to a consideration of their relative biological productivity than of their finite function in recent evolutionary context, either as population barriers or as pools of potential endemism. Nevertheless, by examining the structure of both the fragmented and the coalescent species distributions in relation to the hydrography and geography of the archipelago, mechanisms for isolation and for confluence may be both observed and inferred.

Wyrtki (1961) provides a description of the physical oceanography of southeast Asian waters as a whole, as compared with the detailed picture of the Gulf of Thailand given by Robinson (1974).

Characteristics of inter-basin flow were first considered in the light of data obtained by the *Snellius* expedition (Van Riehl, 1932). The upper water masses of the region are characterized by low salinity, $< 32.5\ ‰$. These are formed year-round, largely over the Sunda Shelf, and contribute neritic or estuarine characteristics, particularly to the shelf region. Evidently, they also enhance the function of the region as a barrier to oceanic species. Salinities in the Strait of Malacca are as low as $30\ ‰$ in February and $28\ ‰$ in August. Flow through this strait and through the Sunda Strait which separates Sumatra from Java are both in the direction of the Indian

Ocean, from the shelf to deep water year-round.

In contrast to the upper layer, the discontinuity layer in the basins is formed of Subtropical Lower Water of high salinity, described by Wyrtki as originating in the tradewind regions of both oceans where high surface salinities prevail. These are to the east of Taiwan and Luzon in the Pacific, and to the south of Java in the Indian Ocean where annual surface salinities are relatively constant. Similarly, all the heavier water lying below the discontinuity layers of the inter-ocean seas originates outside the area. The ability of widely-ranging warm-water plankton species to tolerate the seas may be partly attributable to the oceanic character of sub-surface basin waters.

Inter-ocean flow is weak and variable in direction. The net transport between the Pacific and Indian Oceans is affected by forces acting in each of the several connecting seas. These differ with season: the southern monsoon starts south of the equator as a southeasterly wind, becoming southerly at the equator, and then southwesterly north of the equator. The northern monsoon moves conversely.

BIOGEOGRAPHICAL GROUPINGS IN THE REGION OF THE ARCHIPELAGO

Forty-three tropical and subtropical euphausiid species live in the area of the present study (*Stylocheiron affine* consists here of previously described forms and *S. longicorne* of previously described forms and a new North Indian Ocean Form, here described). The species may be grouped with respect to extent of occurrence along the deep inter-ocean pathway (Table 3).

I. Twelve are oceanic epipelagic species, present throughout the basins of the waterway as well as in adjacent oceans to the east and west. Of these, *Euphausia diomedeae* (Fig. 54), *Nematoscelis gracilis* (Fig. 61b) and *Stylocheiron microphthalma* (Fig. 71) belong only to the Indo-Pacific equatorial assemblage (Brinton, 1962a), the existence of which appears to be a consequence of a waterway connecting similar tropical habitats of the Indian and Pacific Oceans. Nine other species of Group I (e.g., *T. monacantha*, Fig. 47) occur also in the Atlantic, being widely-ranging warmwater cosmopolites. The faunistic affinity of *Stylocheiron affine* West Equatorial Form appears to be solely with the Indo-Pacific tropical group, but confirmation of this must await a study of material from the Atlantic.

II. Five species live at somewhat greater depths than do those of Group I, but appear also to pass between the two oceans along the basin route. These include *Nematobrachion boöpis, Stylocheiron elongatum* and *S. maximum*, which live at and beneath the depth of the thermocline (Brinton, 1967). They were represented in the 0-140 m samples only by occasional young specimens, but adults were present in several of the 2-m net samples from *ca.*400 m depth, and in the deeper of the *Siboga* collections (Hansen, 1910). These are mainly circumglobal species, also having extremely extensive latitudinal ranges (e.g., Figs. 64, 72, 74). It is likely that they are transported between oceans to the south of both Australia and Africa. In contrast, the species of Group I appear not to pass south of Australia and, of this group, only the warm-water cosmopolites appear to have had sufficiently consistent access to waters southwest of Africa to occupy all oceans (e.g., *Euphausia tenera, Stylocheiron carinatum*, Figs. 59, 65).

Of the species in Group II, *Euphausia similis* is anomalous with respect to distribution. Indian Ocean Expedition collections showed two principal zones of distribution: 30° S-50° S and 0°-10° S, with some more northern occurrences in the Somali Current and the Andaman Sea (Brinton and Gopalakrishnan, 1973). These two habitat zones were recognized on the basis of sampling to 200 m depth. Both support breeding populations of *E. similis*. In the Pacific, *E. similis* is abundant only off southern Japan and in the East China Sea, the latter being the primary reproductive area. Adults were consistently caught during the Scripps Antipode expedition near the northern Philippines and were usually found in the deep 2-m net Naga samples from the South China Sea. Larvae were occasionally taken during Naga expedition, but only at

Table 3.

EUPHAUSIID SPECIES, EXTENT OF AUSTRAL-ASIAN REGION OCCUPIED

Group I

Widely Ranging Species Living Also
throughout Region, Upper Layers

Thysanopoda monacantha	(Fig. 47)
T. tricuspidata	(Fig. 45)
Euphausia tenera	(Fig. 59)
E. diomedeae	(Fig. 54b, c)
Nematoscelis microps	(Fig. 61a, c)
Nsc. gracilis	(Fig. 61b)
Nsc. tenella	(Fig. 60)
Stylocheiron carinatum	(Fig. 65)
S. affine	
(West Equatorial Form)	(Fig. 68)
S. longicorne	
(Long, Short Forms)	(Fig. 73)
S. microphthalma	(Fig. 71)
S. abbreviatum	(Fig. 75a, c)

Group IV

Species Largely Restricted from the
Inter-Ocean Pathway Region

Thysanopoda astylata	(Fig. 49)
T. aequalis	(Fig. 49)
T. obtusifrons	(Fig. 50)
T. pectinata	(Fig. 46a, c)
T. cristata	(Fig. 46b, c)
Euphausia paragibba	(Fig. 57b, c)
E. sanzoi	(Fig. 56)
E. fallax	(Fig. 56)
E. mutica	(Fig. 52)
E. brevis	(Fig. 53)
Nematobrachion flexipes	(Fig. 63a, c)
Nb. sexspinosus	(Fig. 63b, c)
Stylocheiron affine	
(Central Form)	(Fig. 70)
S. suhmii	(Fig. 66)

Group II

Living throughout Region
Deep (>200m) Layers.

Thysanopoda orientalis	(Fig. 48)
Euphausia similis	(Fig. 55)
Nematobrachion boöpis	(Fig. 64)
Stylocheiron elongatum	(Fig. 71)
S. maximum	(Fig. 74)

Group V

Species Totally Restricted from
the Inter-Ocean Pathway Region.

Euphausia recurva	(Fig. 54a, c)
E. hemigibba	(Fig. 57a, c)
E. gibba	(Fig. 57a, c)
Nematoscelis atlantica	(Fig. 62)
Stylocheiron robustum	(Fig. 75b, c)
S. indicus	(Fig. 67a)
S. longicorne	
(North Indian Ocean Form)	(Fig. 73a)

Group III
Endemic to or Centered in
the Inter-Ocean Seas

Euphausia pseudogibba	(Fig. 57b, c)
E. sibogae	(Fig. 58)
Pseudeuphausia latifrons	(Fig. 51)
Nematoscelis lobata	(Fig. 62)
Stylocheiron affine	
(Indo-Australian Form)	(Fig. 69)
S. insulare	(Fig. 67)

the most northern stations in the South China Sea, 14-16° N. The four localities in the Halmahera Sea, Banda Sea and Macassar Strait (a few adults and juveniles only) provide evidence for continuity, however tenuous, between Pacific Ocean and Indian Ocean populations of *E. similis*.

It is not known whether the bathypelagic euphausiids, *Bentheuphausia amblyops, Thysanopoda egregia* and *T. cornuta*, occur across the inter-ocean basins. Young of all three were recorded from deep (0-400 m) South China Sea samples, and the *Siboga* records included two localities for *B. amblyops* in the Banda Sea. *Bentheuphausia amplyops* and *T. egregia* at least, occur to the south of Australia, indicating circumglobal continuity in the bathypelagic habitat.

III. Six species make up this diverse group. All are associated mainly with the inter-ocean region and to some extent with the oceans to the east and west.

Pseudeuphausia latifrons (Fig. 51) is the tropical Indo-Pacific neritic species.

Euphausia sibogae (Fig. 58) occurs in the Sulu, Celebes and Molucca Seas and along the eastern side of the South China Sea, but not off Viet Nam or in the Gulf of Thailand. *Siboga* collections from the Ceram and Banda Seas, made during August-September 1899 (Hansen, 1910) yielded a number of records, but *E. sibogae* was not found in those seas either by Naga (April, 1961) or the Monsoon expedition (October, 1960).

Indian Ocean records from the Arabian Sea, Bay of Bengal and the south coasts of Sumatra have been ascribed to *E. distinguenda*, but the specimens appear to be like or identical to *E. sibogae* (see taxonomic discussion). Evidence is therefore inconclusive with regard to the present day state of continuity among the four regions of occurrence of this species: (1) Philippines-Molucca Sea, (2) Coral Sea, (3) south of Java-Sumatra, and (4) Arabian Sea-Bay of Bengal. It appears likely that they are in contact on an intermittent, possibly annual, basis. The seasonal reversal of certain currents, effected by the monsoon winds, is a mechanism capable of bringing about seasonal coalescence or fragmentation of species distributions among seas. Year-to-year variation in the seasonal cycle is also to be expected (see discussion).

Euphausia pseudogibba (Fig. 57) and *Stylocheiron affine* Indo-Australian Form (Fig. 69) consistently occur in the inter-ocean basins. Records south of Java indicate the possibility of some communication between the Bay of Bengal population and the inter-ocean basin population, in both *E. pseudogibba* and *S. affine* (I-A Form).

All known localities for *Nematoscelis lobata* and *Stylocheiron insulare* are shown in Figs. 62, 67. *Nematoscelis lobata* is confined to Philippine waters, while *S. insulare* is more broadly though sparsely scattered, from the Andaman Sea eastward through the archipelago to the Solomon Islands. The connections are apparently via the south coast of Java and the inter-ocean basin, not including the South China Sea.

IV. Twenty species occurring in the Indo-Australian region are, to differing degrees, excluded from the inter-ocean pathway. Group IV consists of 14 species, the Pacific and Indian Ocean populations of which are less clearly separated by the pathway-barrier region than are those of species in Group V.

Of the species pair *Thysanopoda aequalis-T. astylata*, the former is predominant 0°-30° S in the Indian Ocean (Brinton and Gopalakrishnan, 1973) and 0°-35° N in the western Pacific (Brinton, 1962a). It is the species occurring in the South China Sea. The three Banda and Timor Sea records of *T. aequalis* (Fig. 49) may represent a connecting or "puddle jump" habitat. The range of *T. astylata*, (Fig. 49) mirrors that of *T. aequalis* in the Indian Ocean and western Pacific:it occurs primarily north of the equator in the Indian Ocean and south of it in the western Pacific. Two records from the Banda Sea and two from south of Java suggest the possibility of an even more tenuous inter-ocean communication than in the case of *T. aequalis*.

Thysanopoda obtusifrons (Fig. 50), *T. pectinata* (Fig. 46) and *T. cristata* (Fig. 46) were lacking in the Ceram, Banda and Flores Seas. *T. obtusifrons* was recorded from the Molucca passage, while *T. pectinata* and *T. cristata* appeared in both the Celebes and Timor Seas.

Euphausia paragibba (Fig. 57), of the tropical Indo-Pacific species group, is entirely replaced

in the inter-ocean basins by *E. pseudogibba* (of Group III, above). There is one record from the Halmahera Sea, apparently at the western limit of the Pacific range of this oceanic species.

Euphausia sanzoi and *E. fallax* appear scattered about in Indo-Australian waters, and westward to the Arabian Sea and African coast. *E. sanzoi* (Fig. 56) occurs regularly in the South China Sea, around the Philippines, to the east of the Solomons and New Hebrides, and in the Indian Ocean, exclusive of the Andaman Sea where *E. fallax* (based on young specimens only) is abundant. In inter-ocean waters, *E. fallax* has been confirmed only from the Sulu Sea region and the Halmahera Sea to the south, with the possibility of records near the Solomons and in the Coral Sea (young, post-larval specimens). *E. sanzoi* was found in the Banda Sea, and a single larva was caught south of Java. These two species may well be "swarmers" and occupants of slope waters, and therefore only fortuitously sampled.

Euphausia mutica (Fig. 52) is rare but present in the Banda, Ceram and Molucca Seas. Similarly, there is evidence that the sparsely occurring species *Nematobrachion flexipes* and *N. sexspinosus* (Fig. 63) and *Stylocheiron affine* (Central Form) (Fig. 70) occur, though sporadically, in the connecting seas.

Euphausia brevis (Fig. 53) and *Stylocheiron suhmii* (Fig. 66) were not caught south of Halmahera. Both are considered Central Water Mass species (Brinton, 1962a), having distributions that may indeed be interrupted between the two oceans, just as their North Pacific and South Pacific populations appear separated by equatorial waters in the oceanic region to the east.

V. This group consists of species which occur in waters neighboring the inter-ocean region but which do not penetrate those seas today. *Euphausia hemigibba* (Fig. 57) occurs in the North and South Indian Ocean (like *Thysanopoda aequalis*: *E. gibba* (Fig. 57) occurs in the South Pacific only; *E. recurva* (Fig. 54) and *Nematoscelis atlantica* (Fig. 62) live in the North and South Pacific and the South Indian Ocean. All are characteristic euphausiids of mid-latitudes. It will be noted in the next section however, that these (excepting *E. gibba*) may be found in the northernmost part of the South China Sea during the northeast monsoon season.

Stylocheiron robustum (Fig. 75) apparently extends north-south across the equator in the Pacific, but has been found only to the south of 8° S in the Indian Ocean. There are no records from the inter-ocean seas.

S. indicus (see taxonomic discussion) was found in abundance at a station in the northernmost part of the Sulu Sea (11° 00′N, 121° 34′E) and sparsely at a station southeast of Halmahera, 1°S, 130°E. These and the four localities off southwest India (Silas and Mathew, 1967) are the only known places of occurrence of this species. (The Arabian Sea-Bay of Bengal distribution for *S. indicus* presented in Brinton and Gopalakrishnan (1973) is in error. It is based on a different species, now believed to be either a form of, or a distinct species closely allied with, *Stylocheiron longicorne*, here designated "North Indian Ocean Form"). The extensive IIOE collections, incredibly, did not appear to contain *S. indicus*. The localities off Kerala, India, and the new localities off the Philippines and Halmahera appear to be relict pockets, but as in the case of *E. fallax*, sampling procedures may have been inadequate for this species, a possible "slope swarmer."

DISCUSSION OF INTER-OCEAN BARRIERS/PATHWAYS

There appear now to be sufficient data to justify the charting of distributions on a global basis so as to illustrate certain general features such as presence or absence in a given hemisphere and presence or absence of north-south or east-west continuity in each ocean. However, the extent of present day east-west continuity among tropical or subtropical populations of the three oceans remains difficult to determine in many instances.

Communication between oceans in tropical and subtropical latitudes can occur in four places, each a potential barrier/pathway: the waters of 1) the Indo-Australian Archipelago, 2) the tip of South Africa, 3) southern Australia, and 4) the tip of South America. Red Sea and eastern

Figure 45a.

Thysanopoda tricuspidata

Figure 45b.

Figure 46a.

Thysanopoda pectinata

Figure 46b.

Thysanopoda cristata

Figure 46a,b.

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Figure 46c.

Thysanopoda monacantha

Figure 47a.

84

Figure 47b.

85
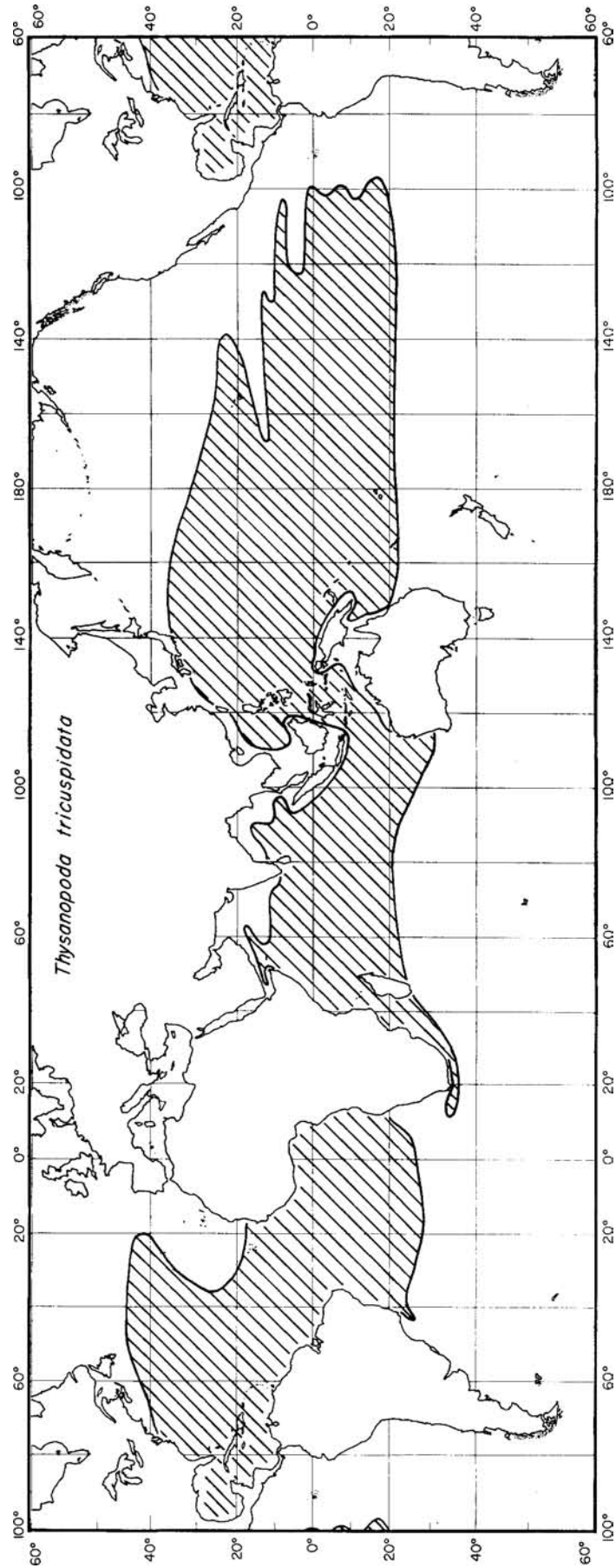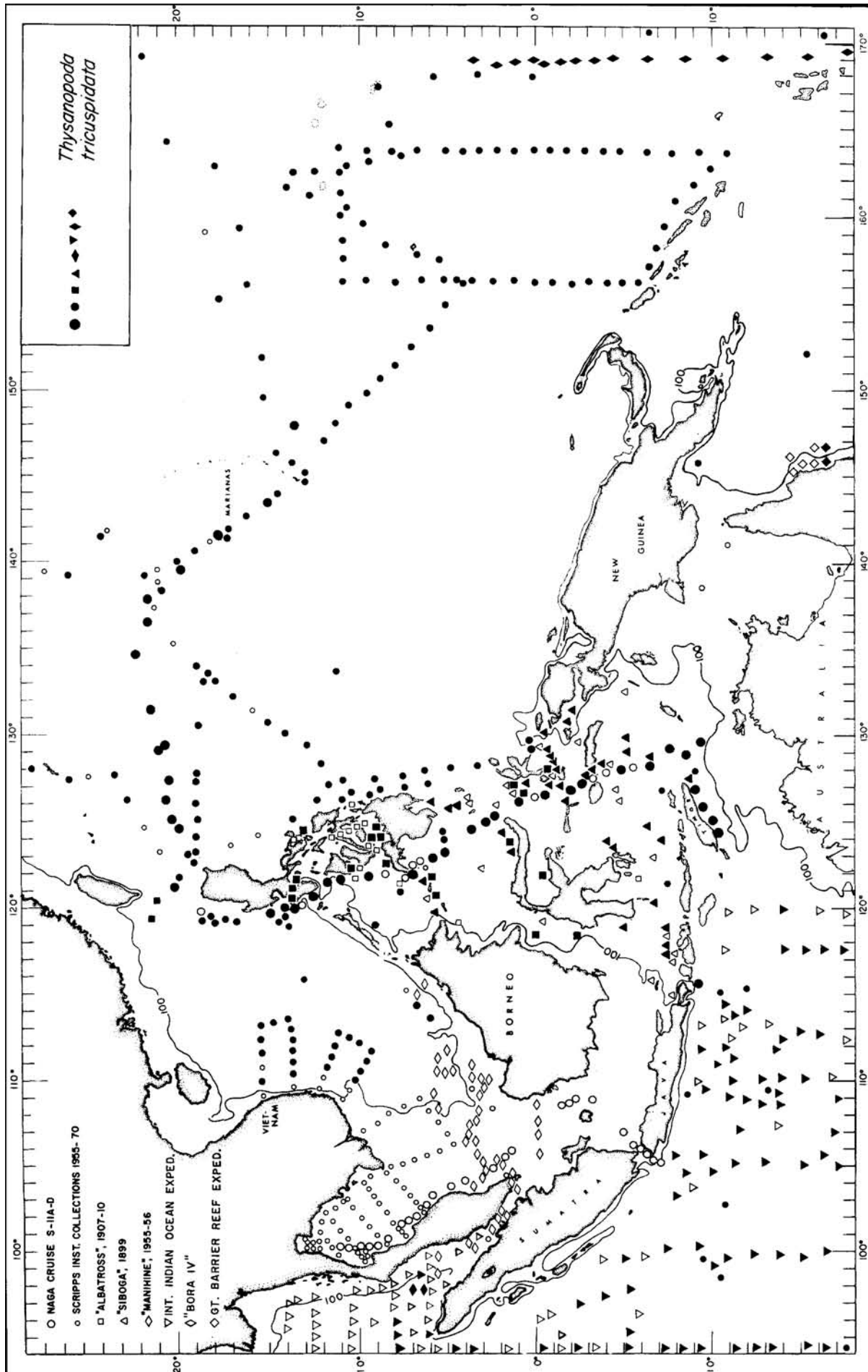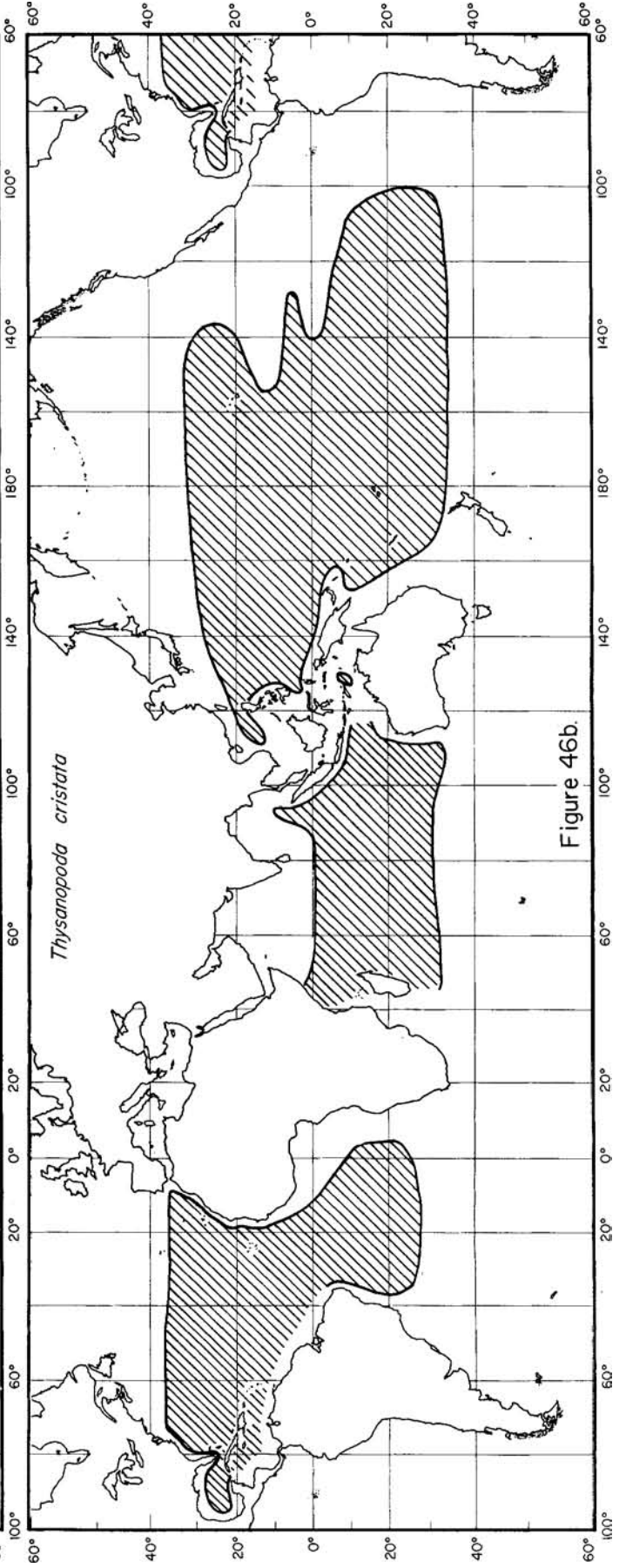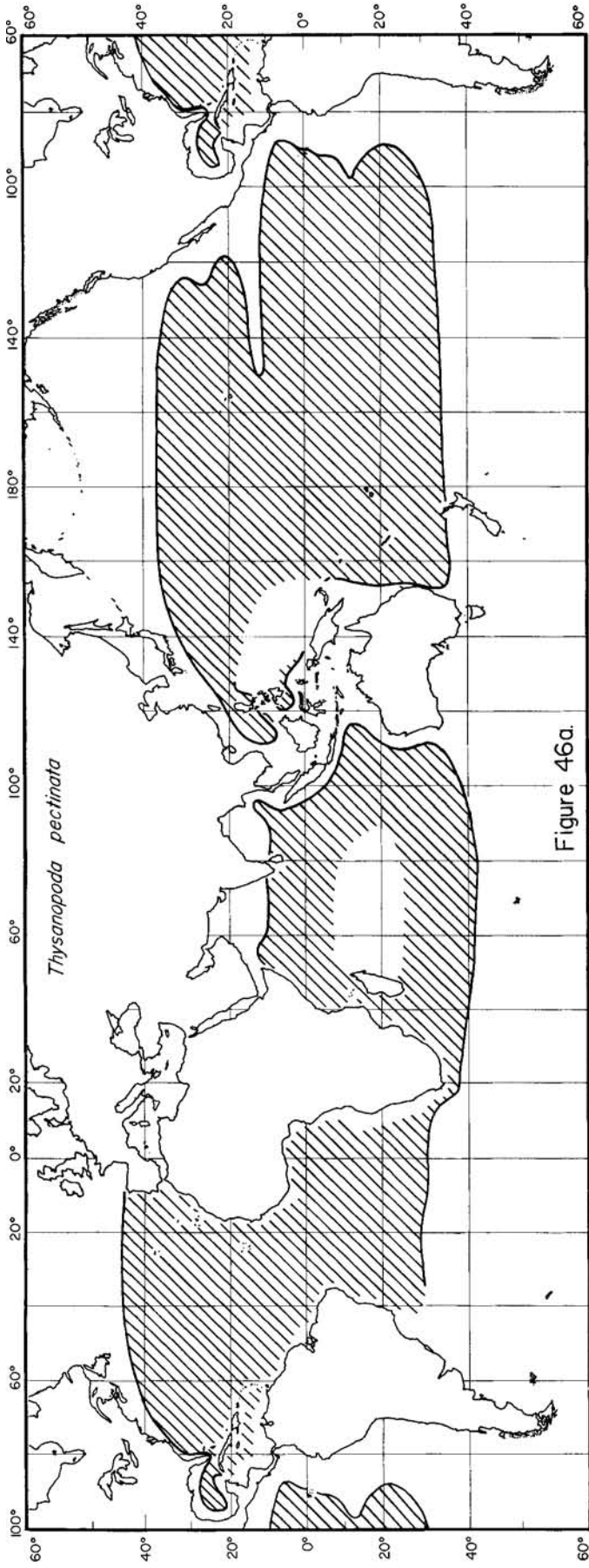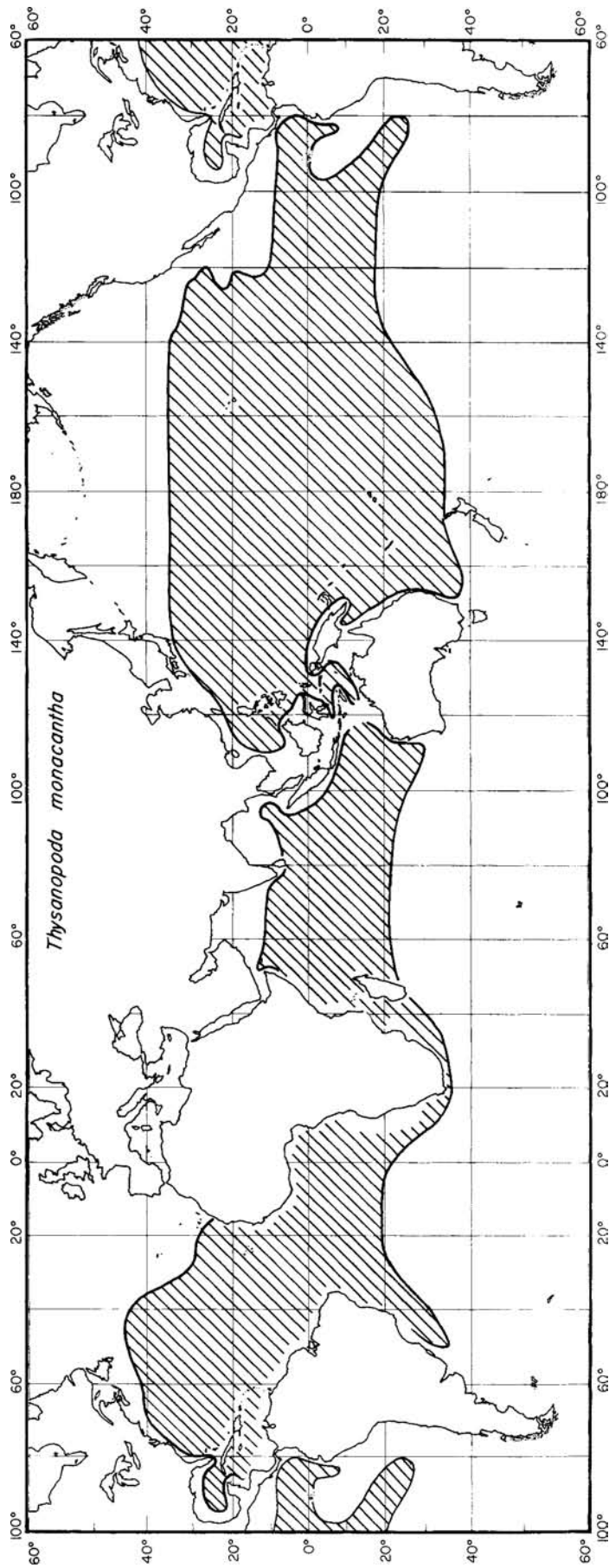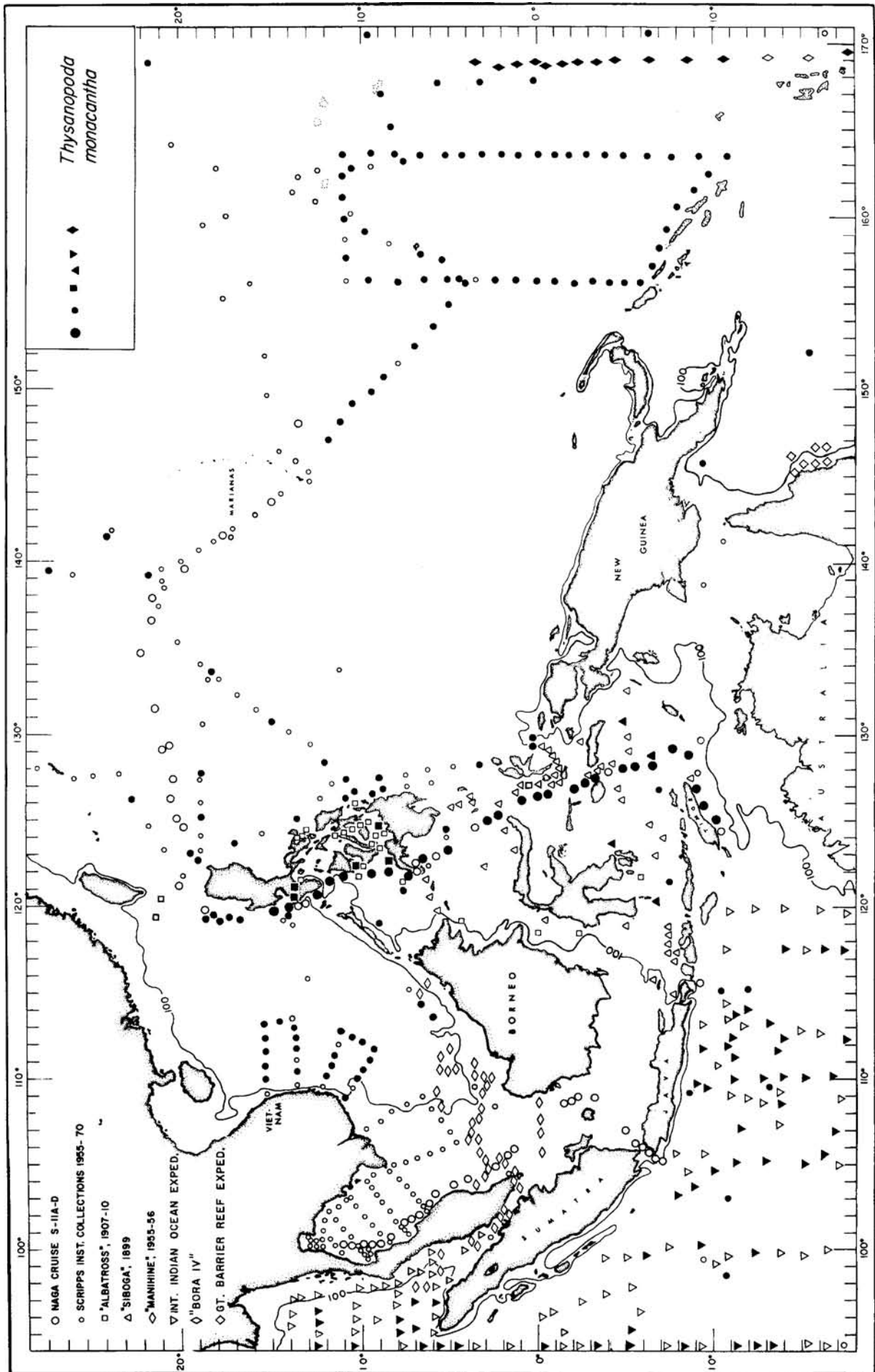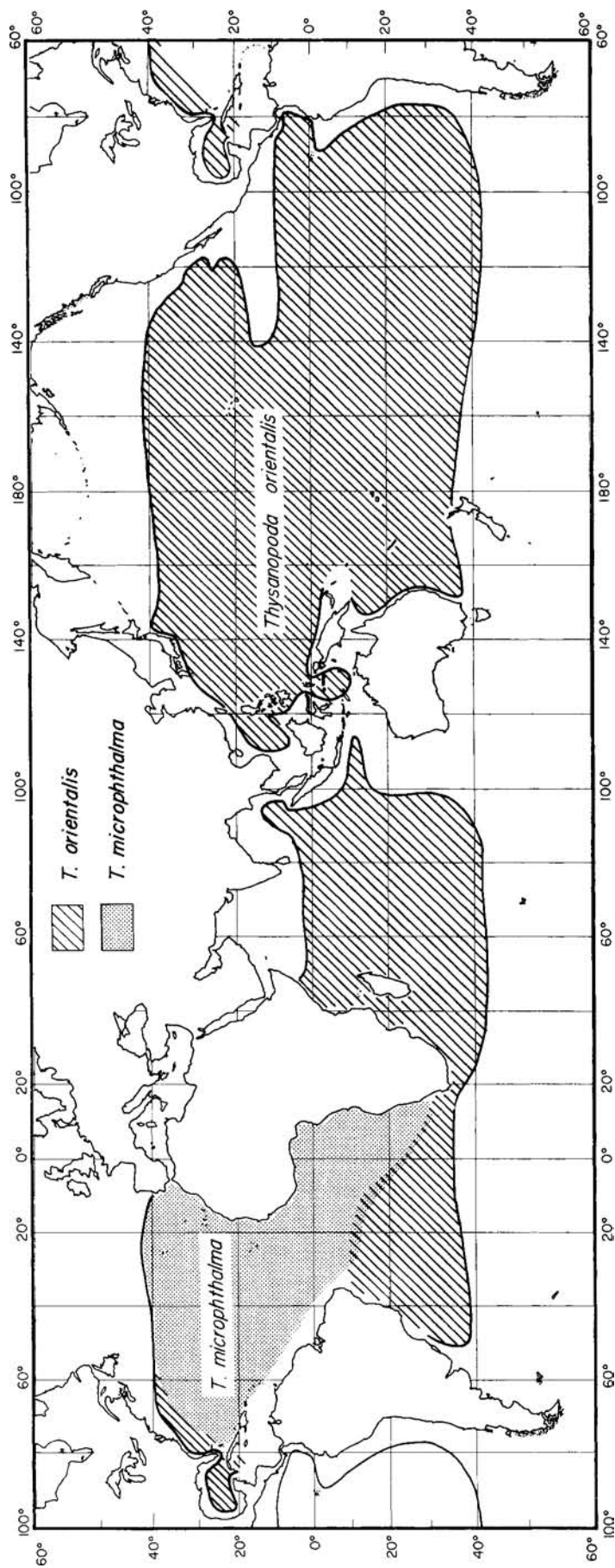
Figure 48a.

Figure 48b.

Figure 49a.

Thysanopoda aequalis

T. astylata

Figure 49b.

Thysanopoda obtusifrons

Figure 50a.

Figure 50b.

Thysanopoda obtusifrons

○ ● ▼ ◆

○ NAGA CRUISE S-IIA-0
○ SCRIPPS INST. COLLECTIONS 1955-70
□ "ALBATROSS", 1907-10
△ "SIBOGA", 1899
◇ "MANIHINE", 1955-56
▽ INT. INDIAN OCEAN EXPED.
◇ "BORA IV"
◇ GT. BARRIER REEF EXPED.

91

Pseudeuphausia latifrons
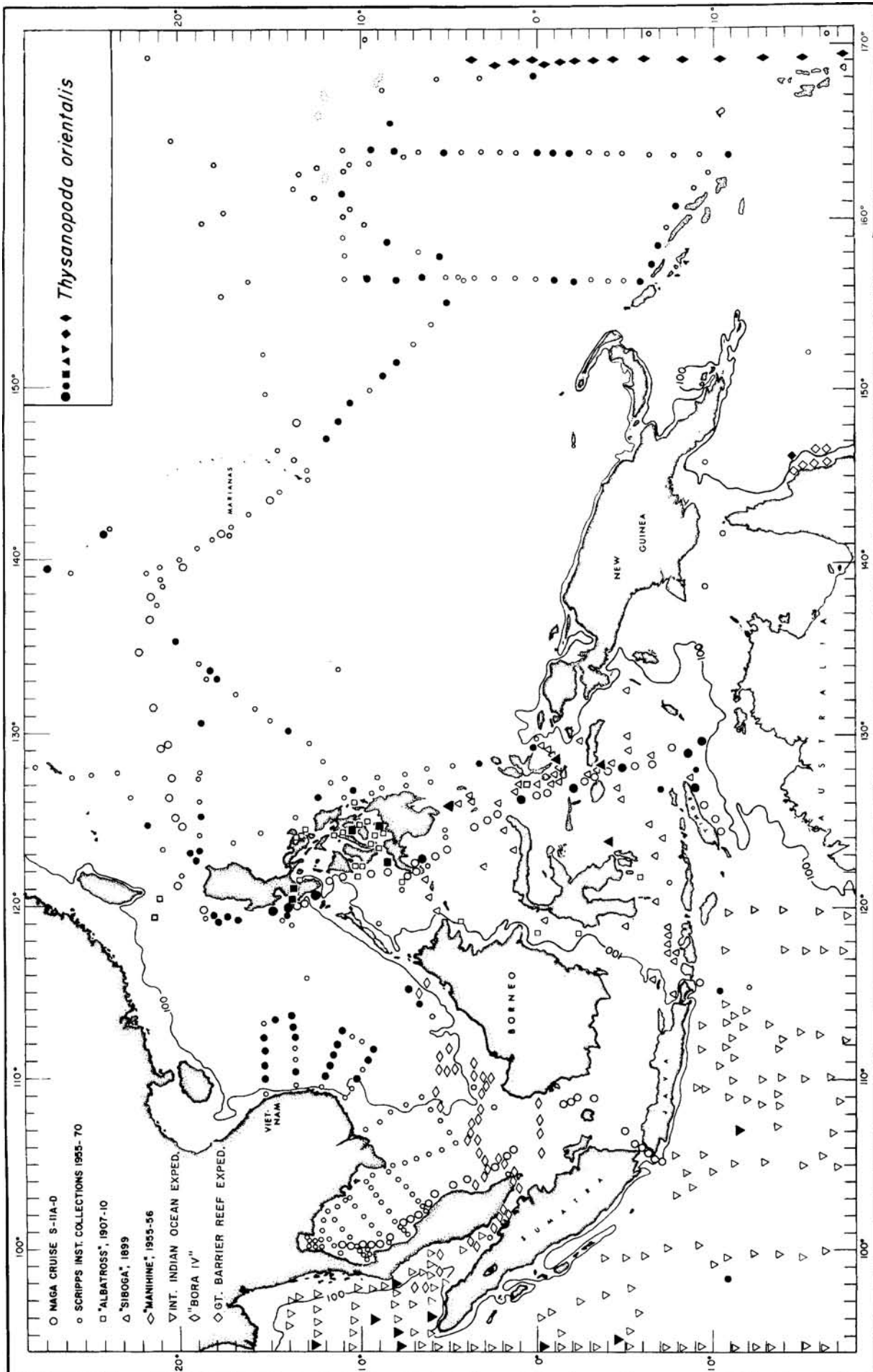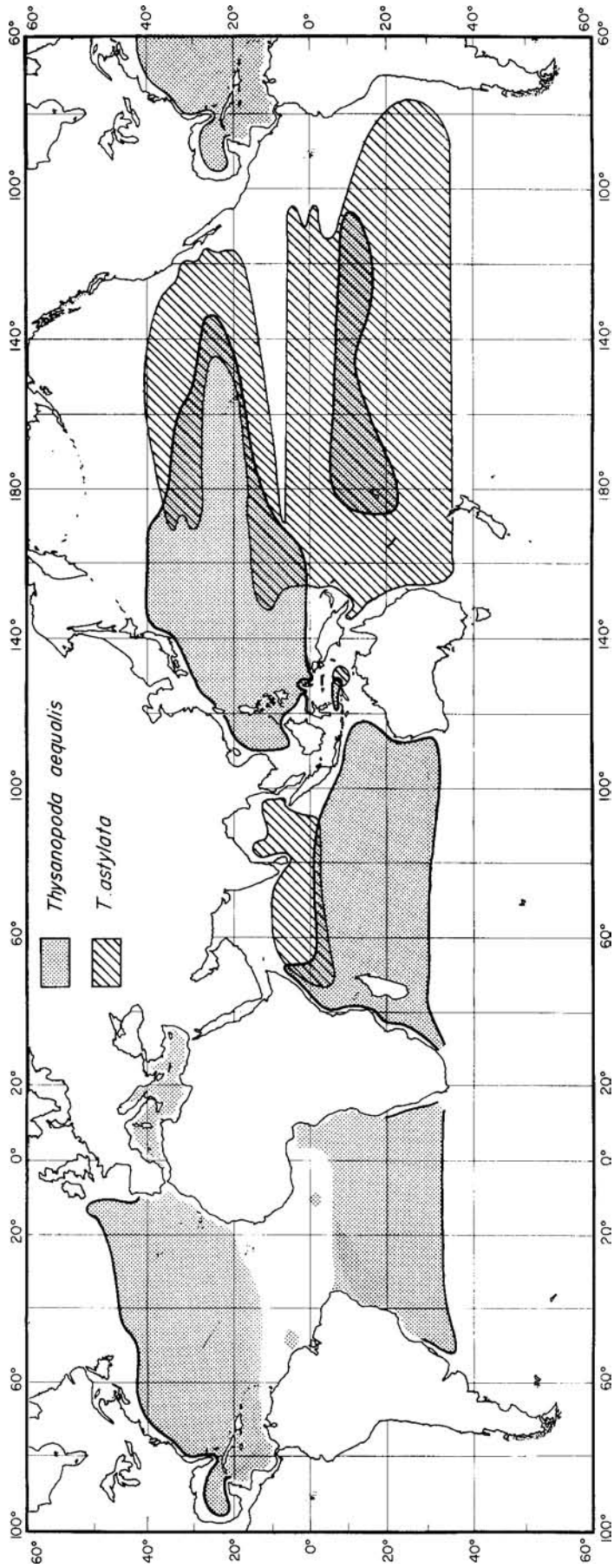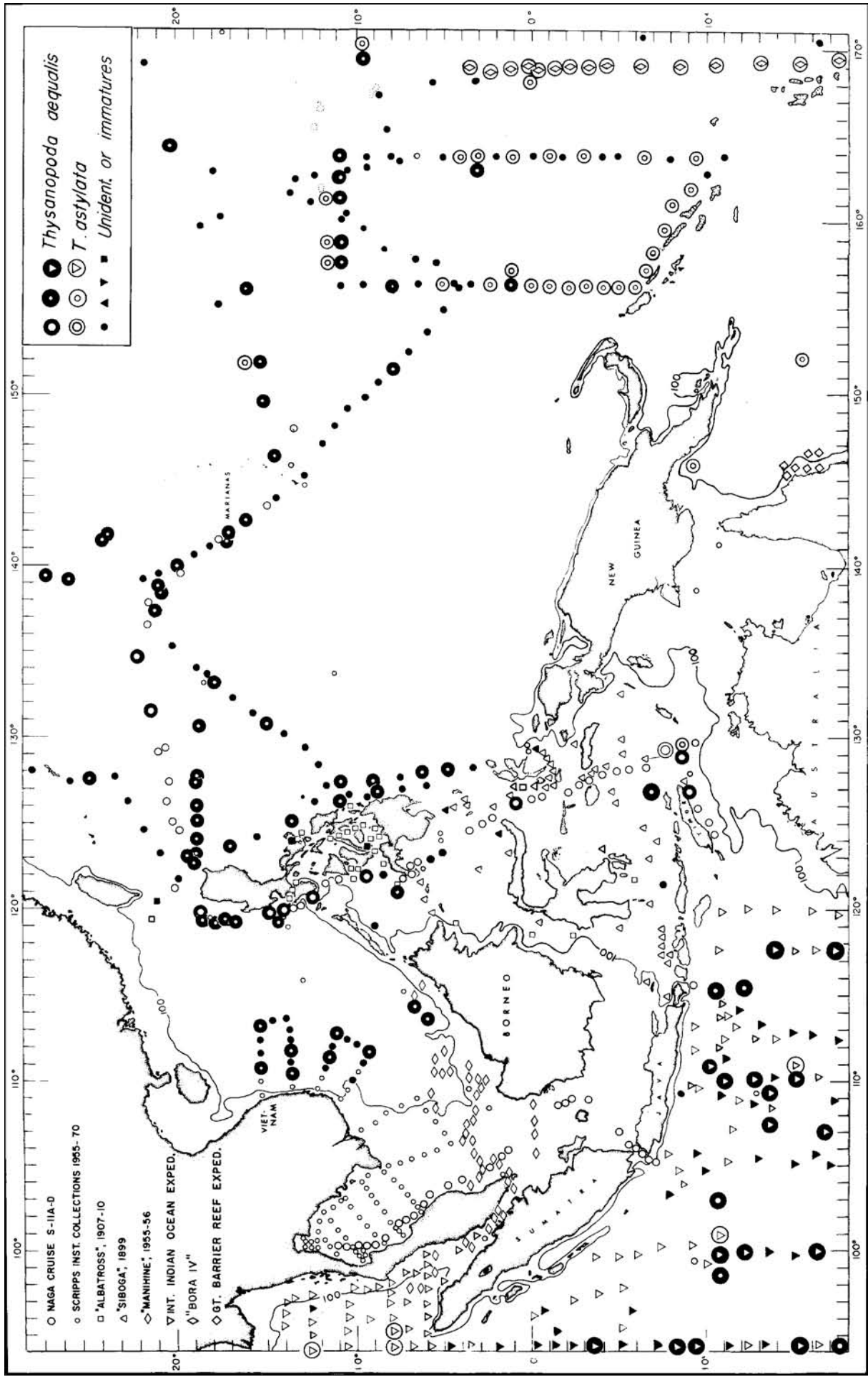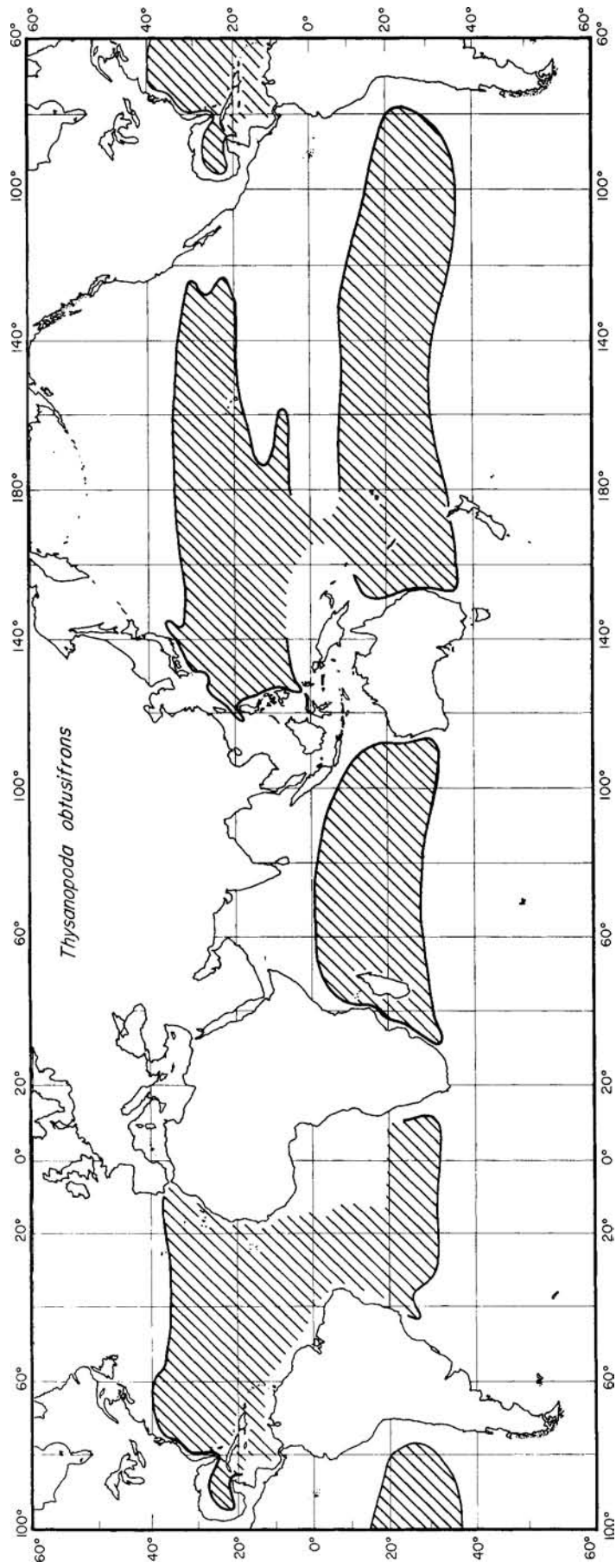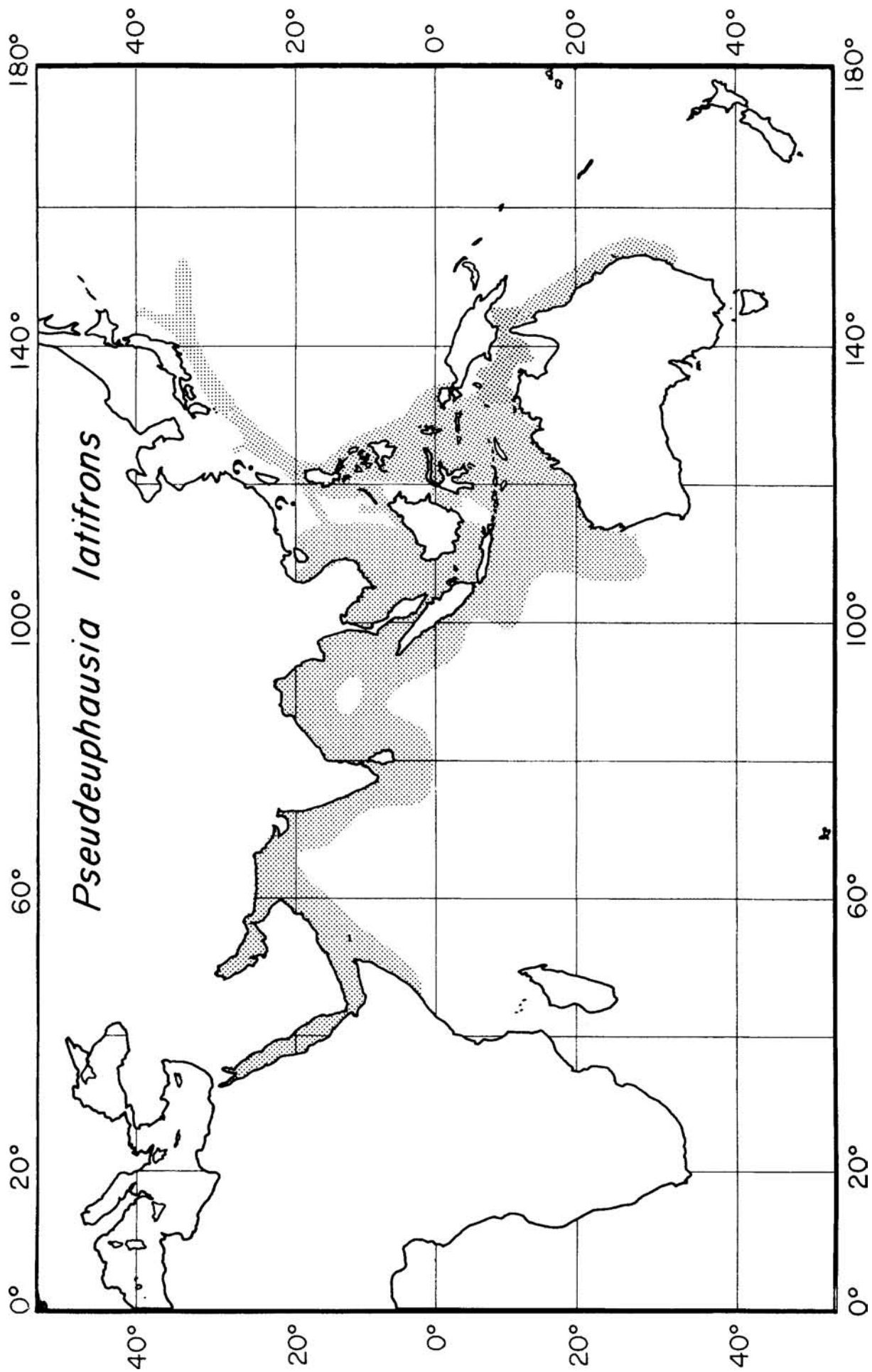
Figure 51a.

Figure 51b.

93

Euphausia mutica
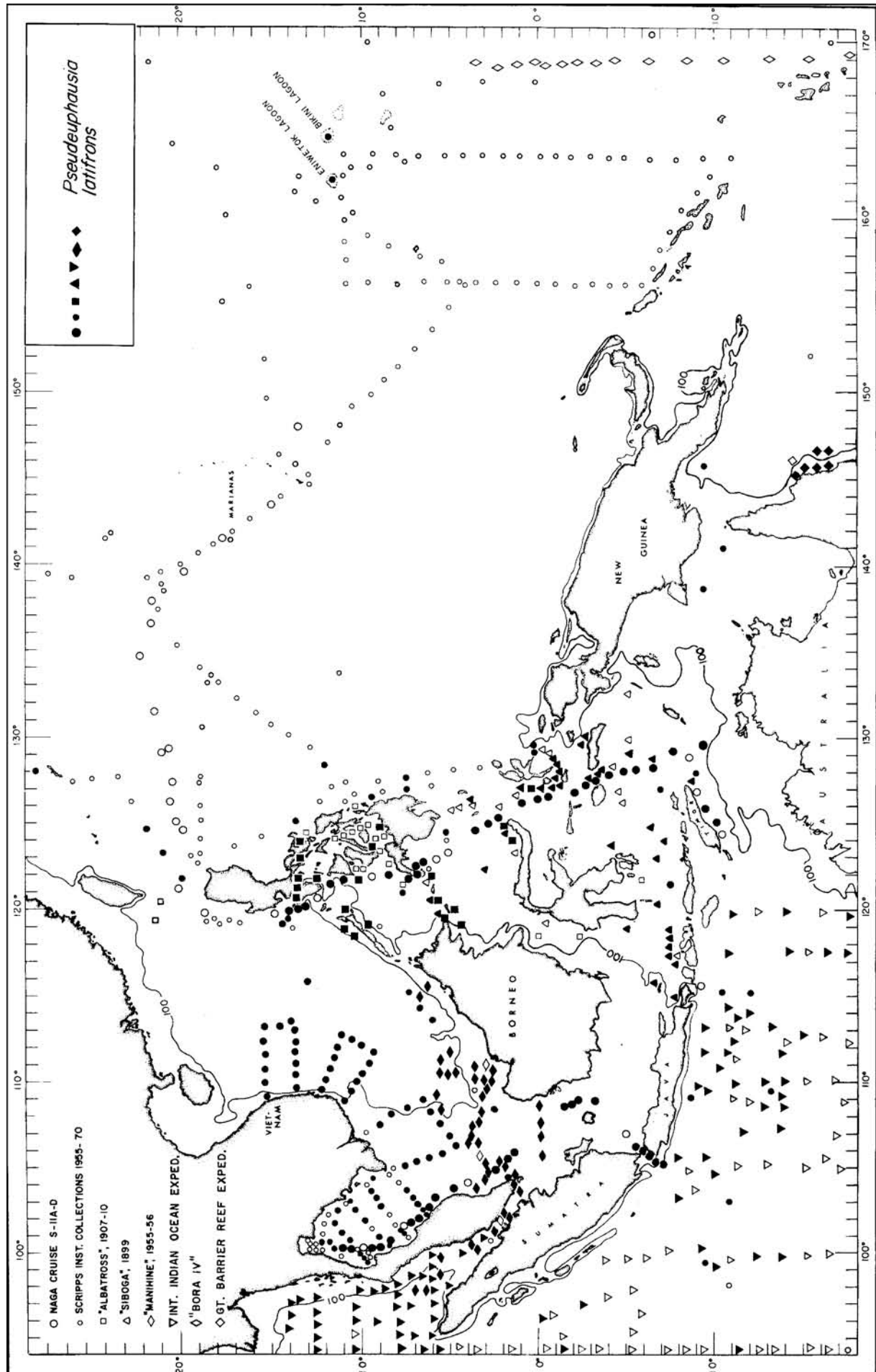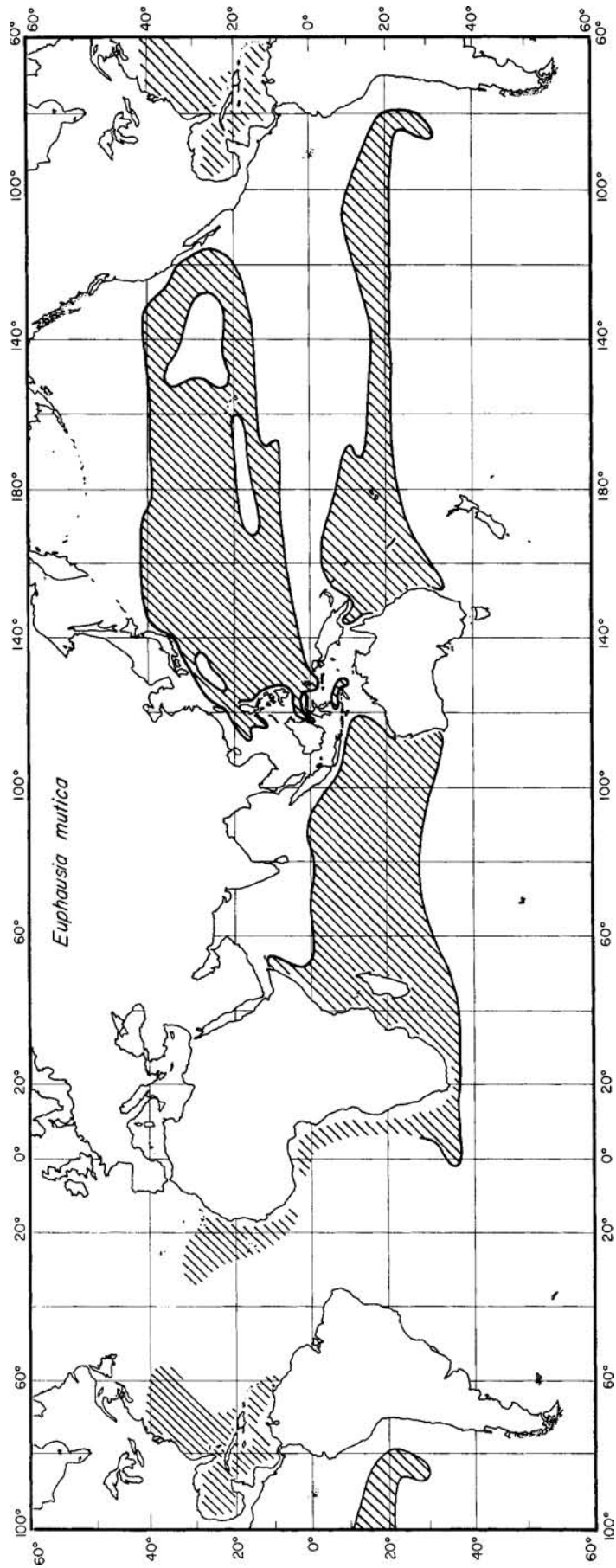
Figure 52a.

Figure 52b.
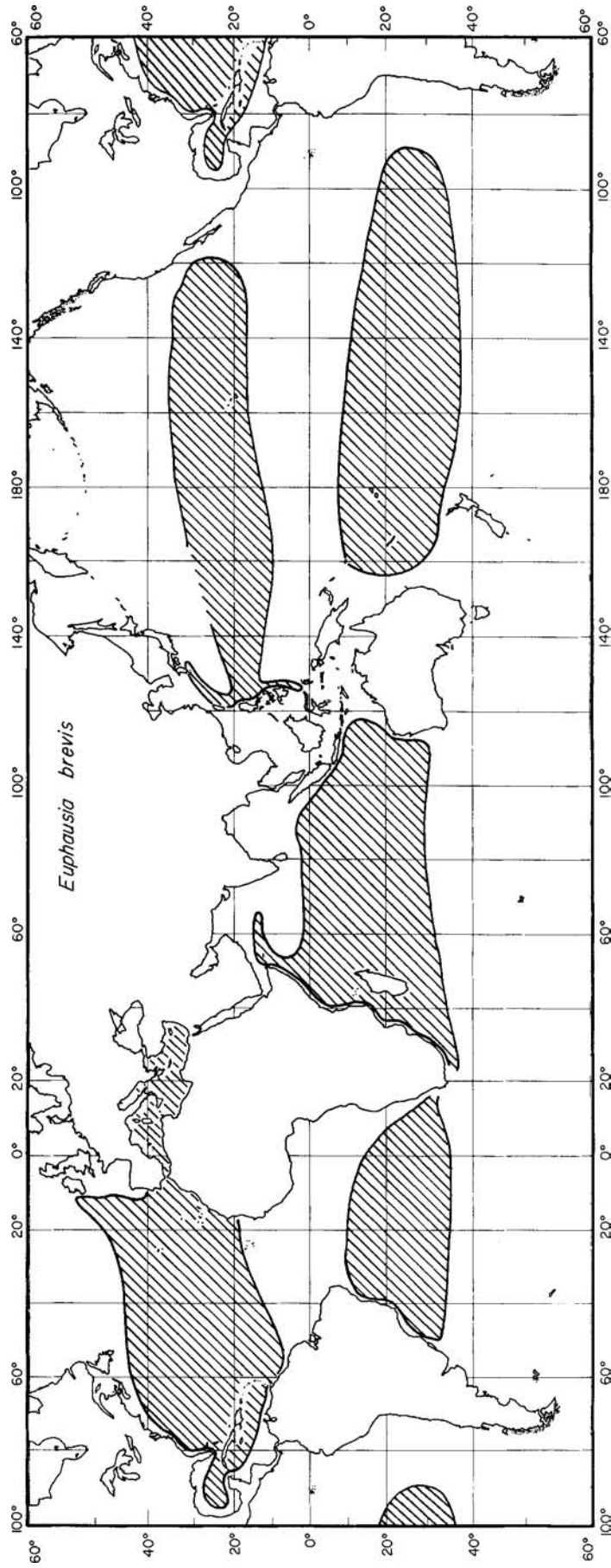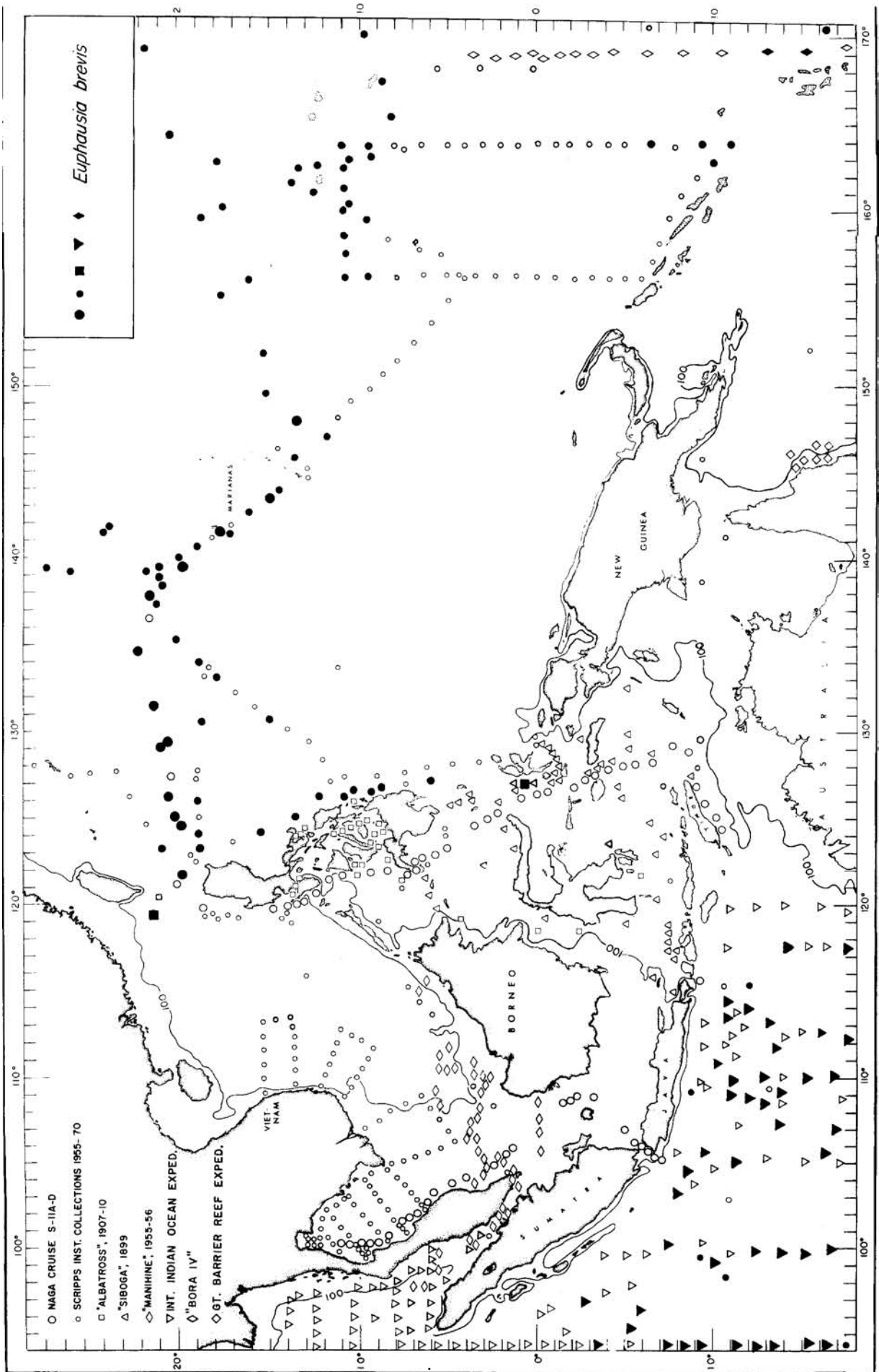
Euphausia brevis

Figure 53a.

Figure 53b

Euphausia recurva

Figure 54a.

Euphausia diomedeae

Figure 54b.

Figure 54a,b.

98

Figure 54c.

Figure 55a.

Euphausia similis

E. similis variety armata

100

Figure 55b.

101

Figure 56a.

Euphausia sanzoi

Euphausia gibboides

Euphausia fallax

102

Figure 56b.

Figure 57a.

Euphausia hemigibba

E. gibba

Euphausia pseudogibba
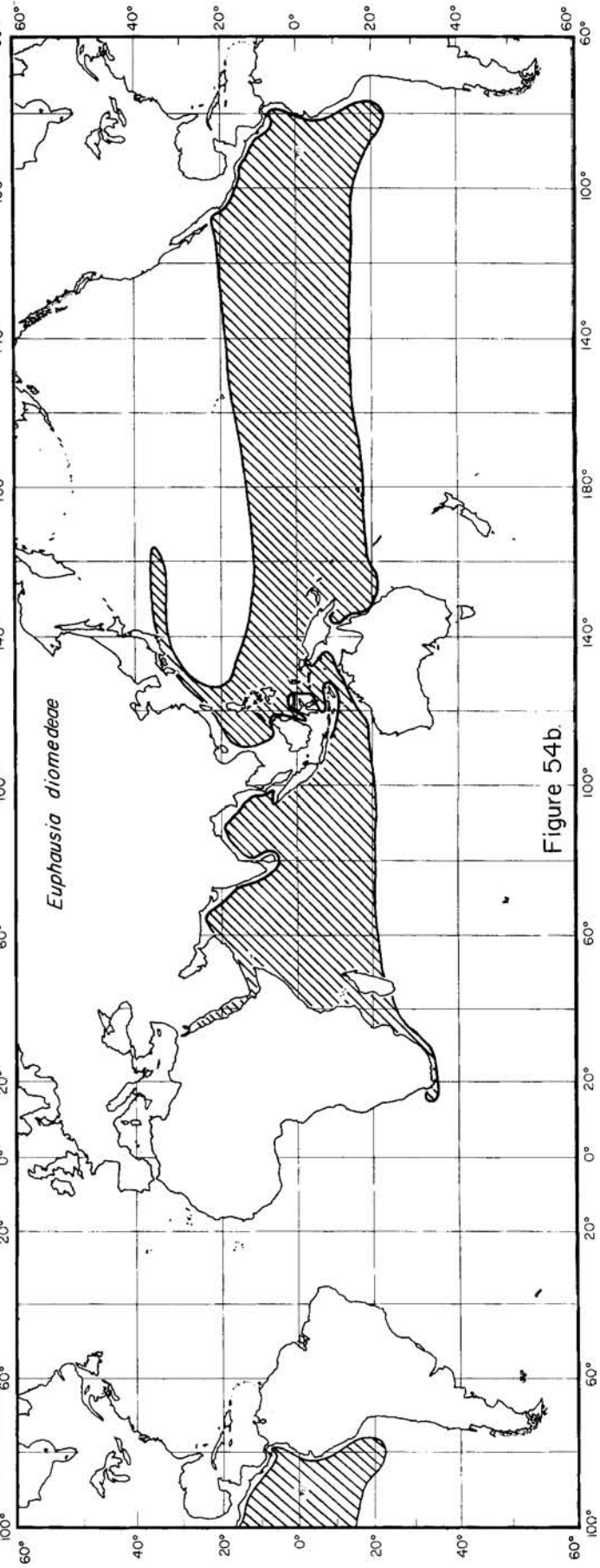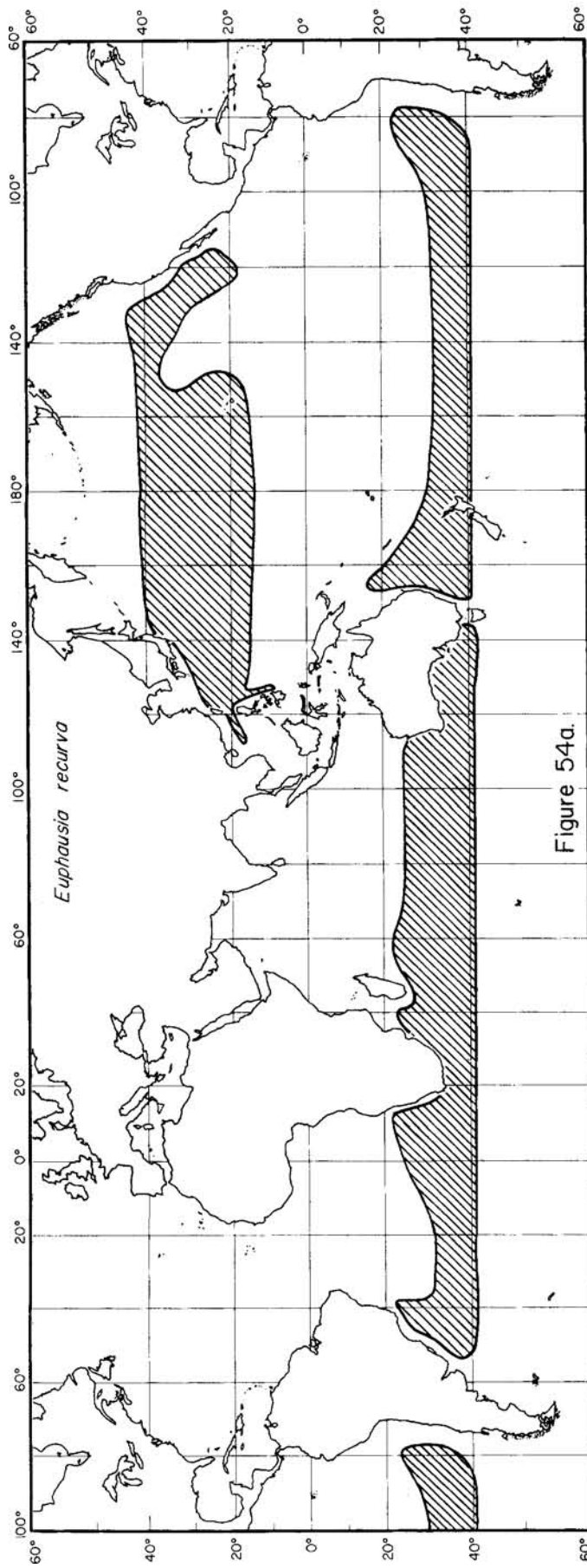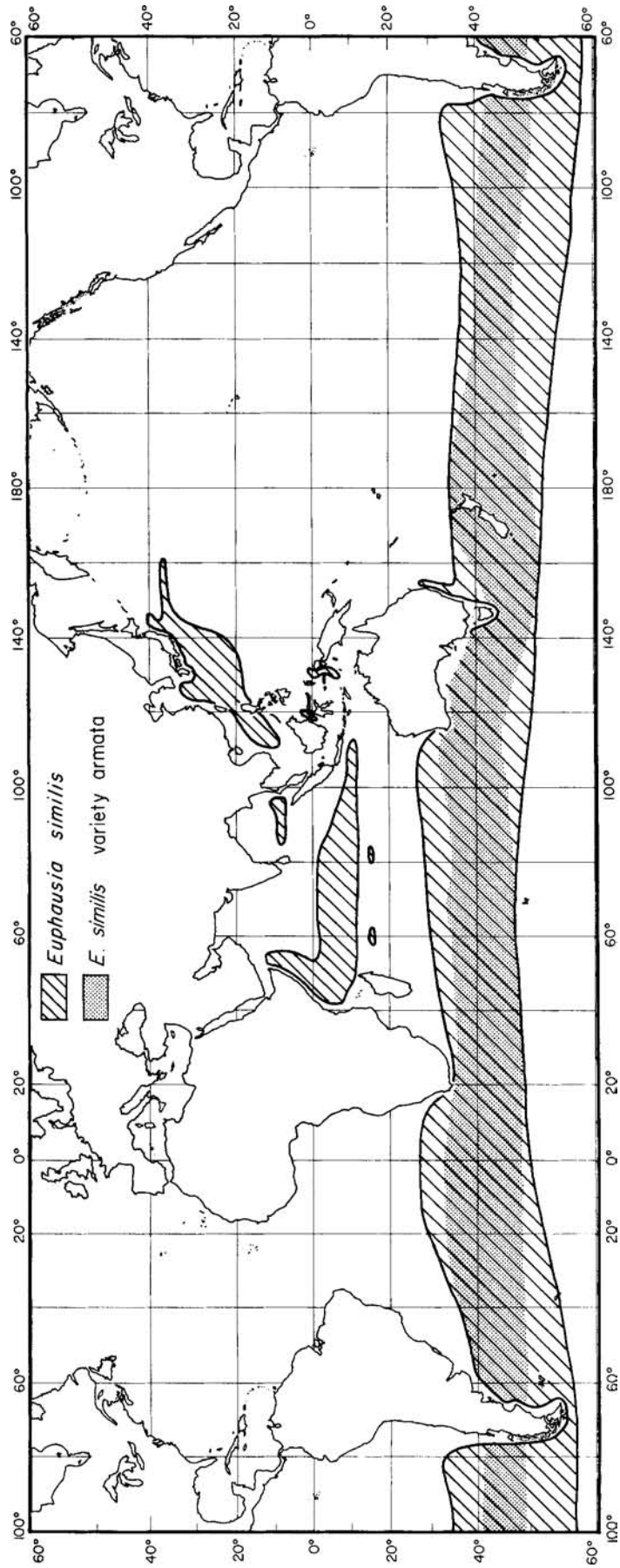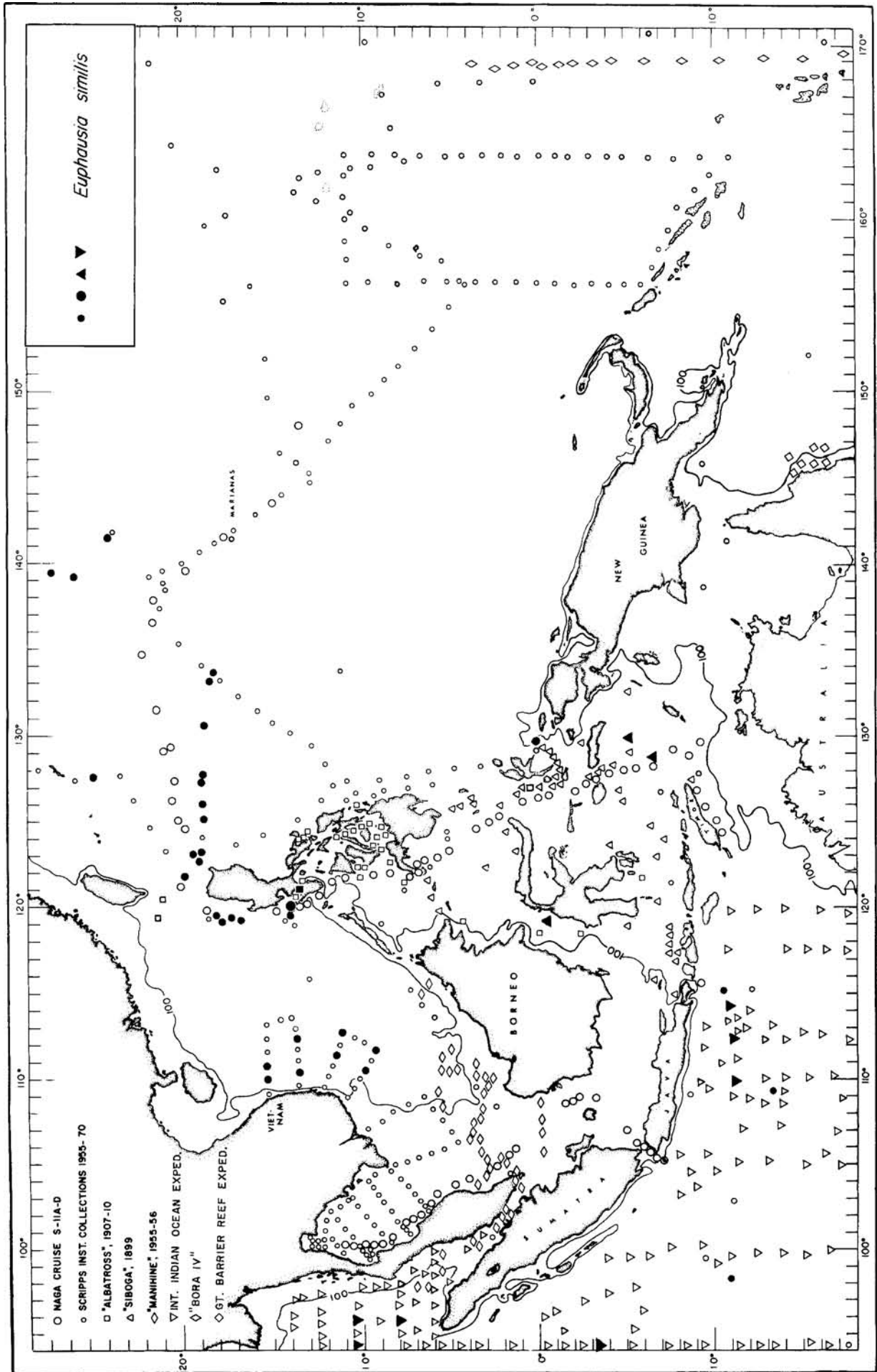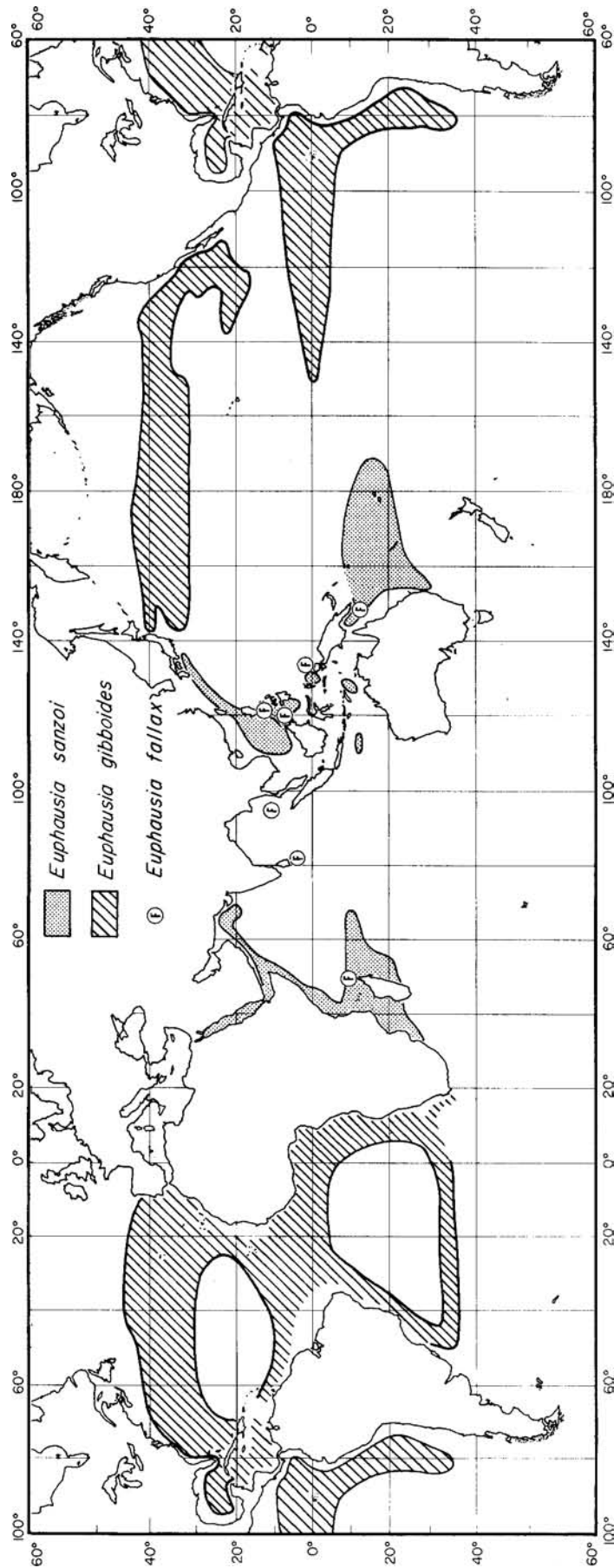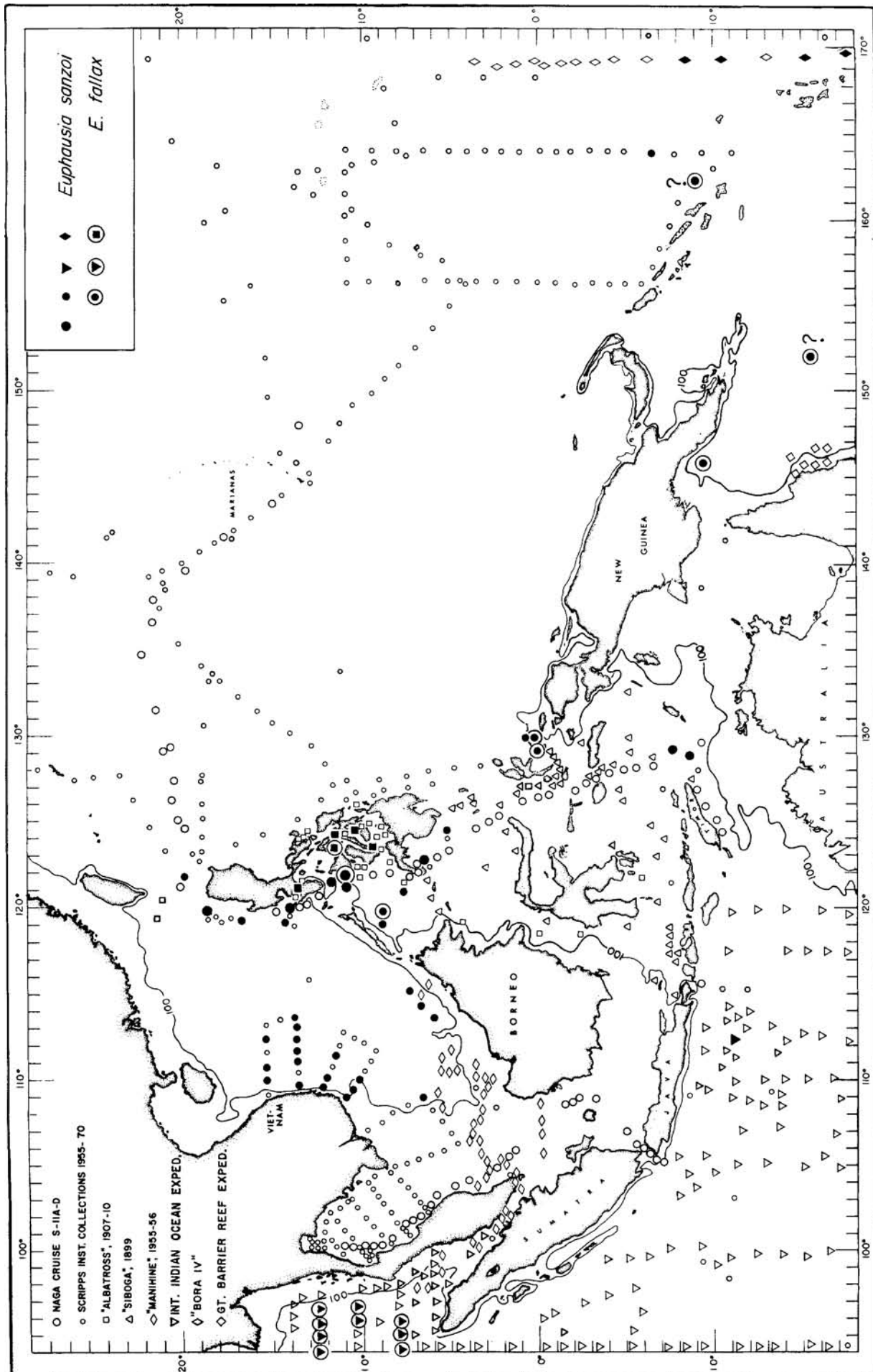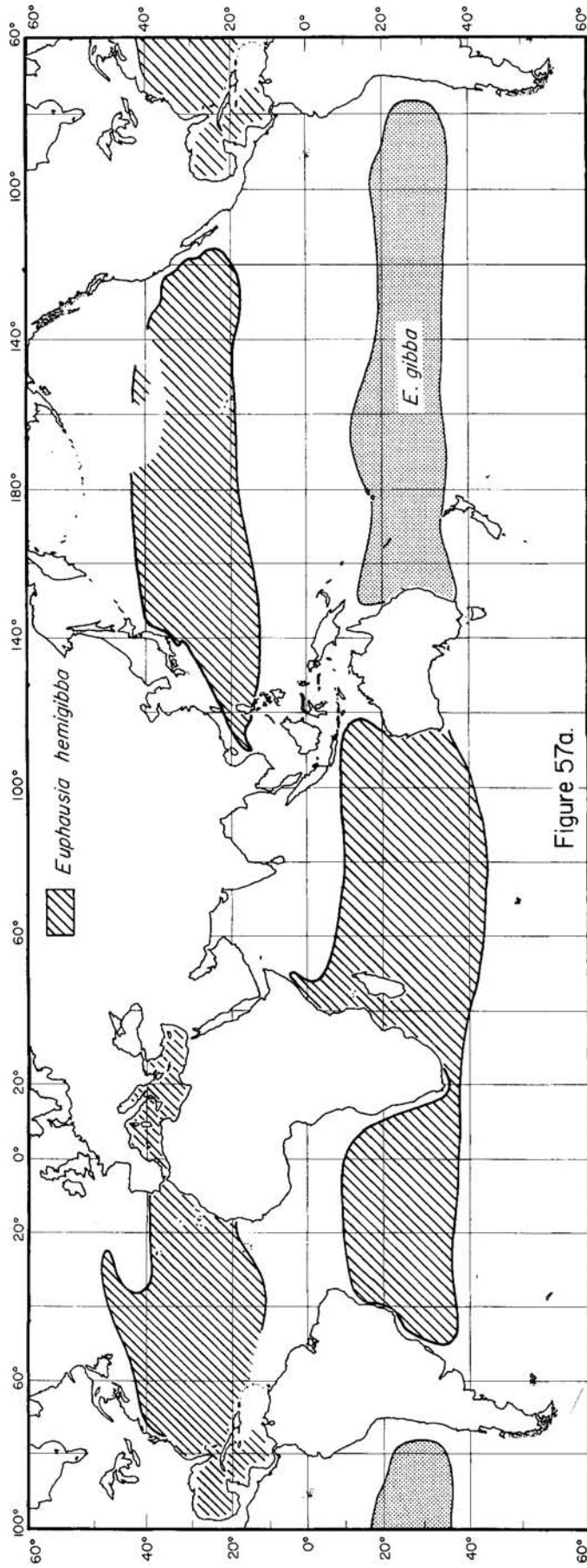
E. paragibba
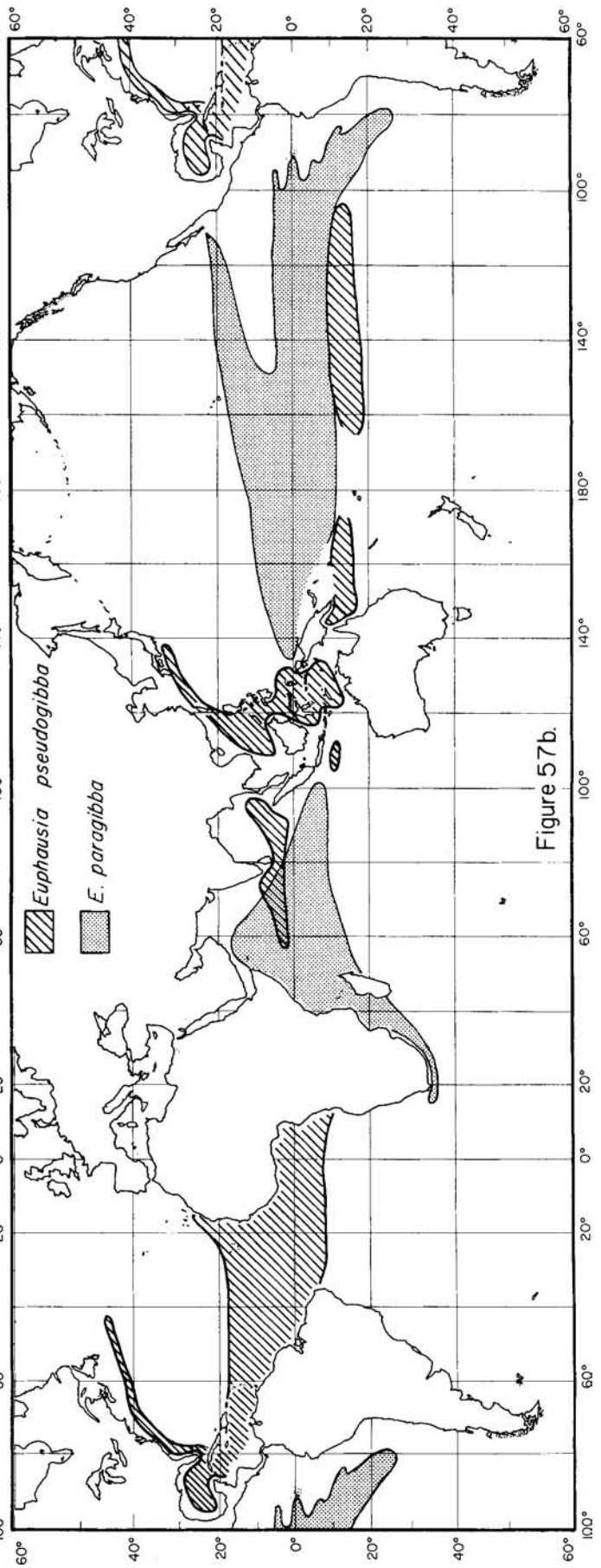
Figure 57b.

Figure 57a,b.

104

Figure 57c.

Figure 58a.

*Euphausia siboga*e

E. distinguenda

Figure 58b.

Euphausia tenera

Figure 59a.

108

Figure 59b.

Nematoscelis tenella
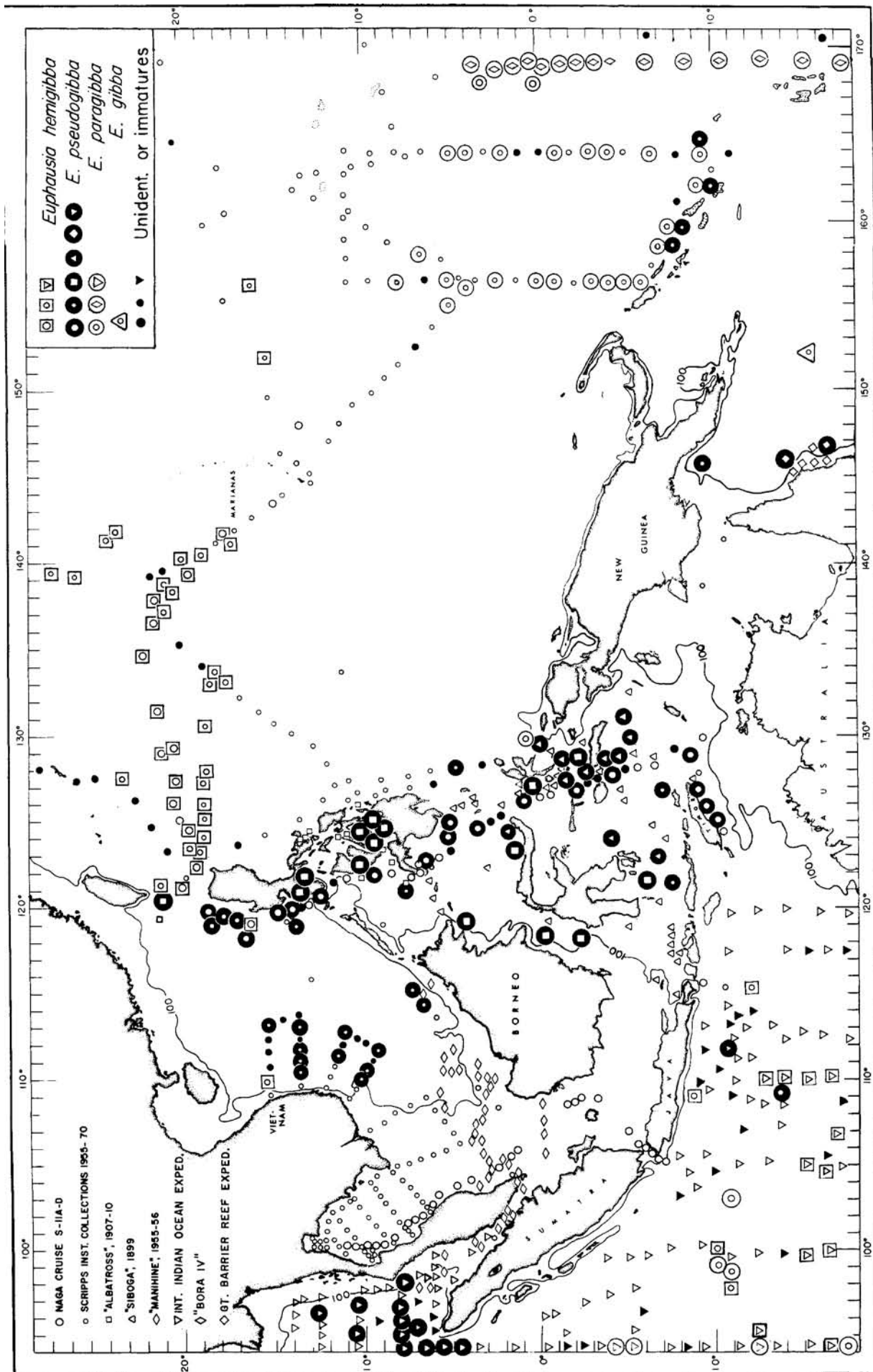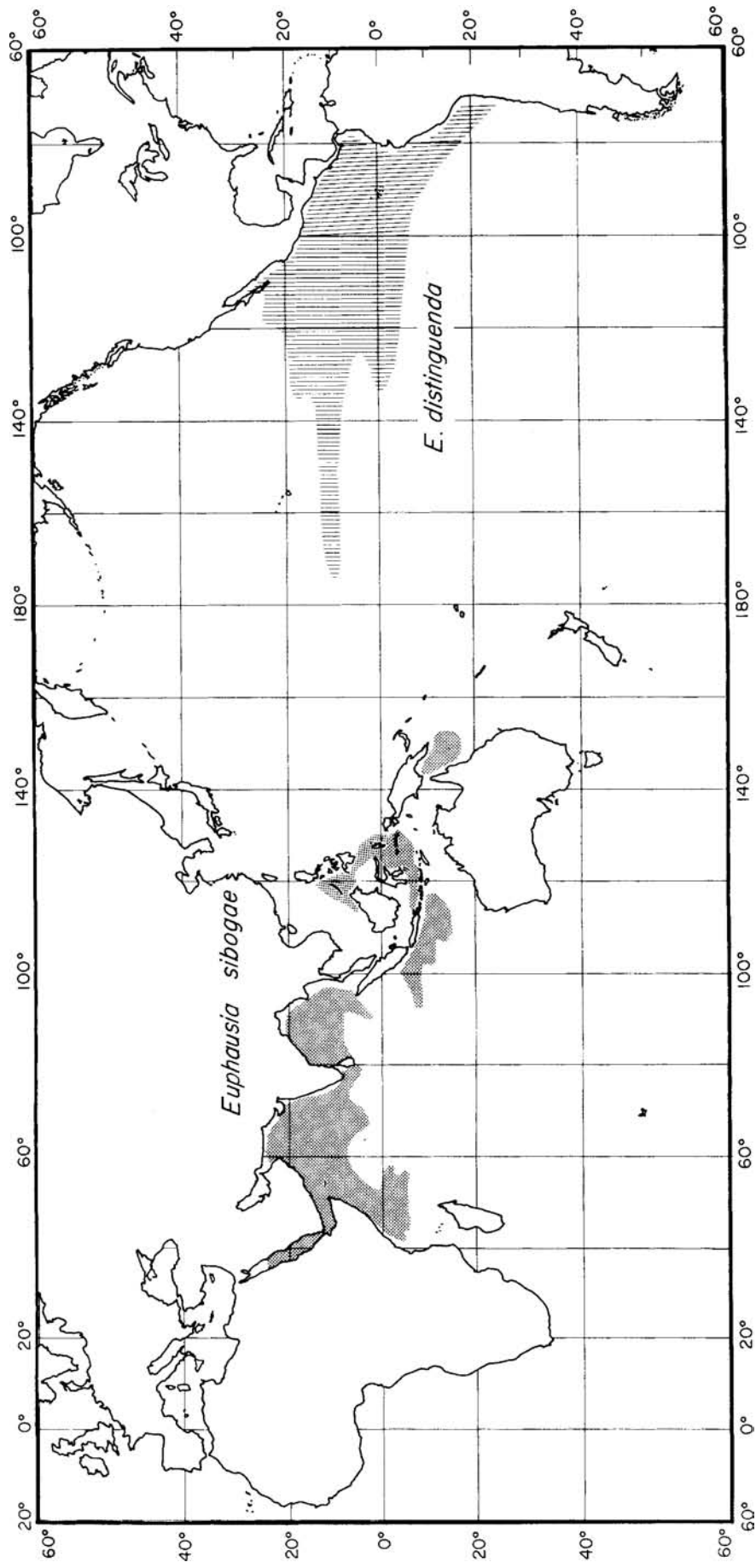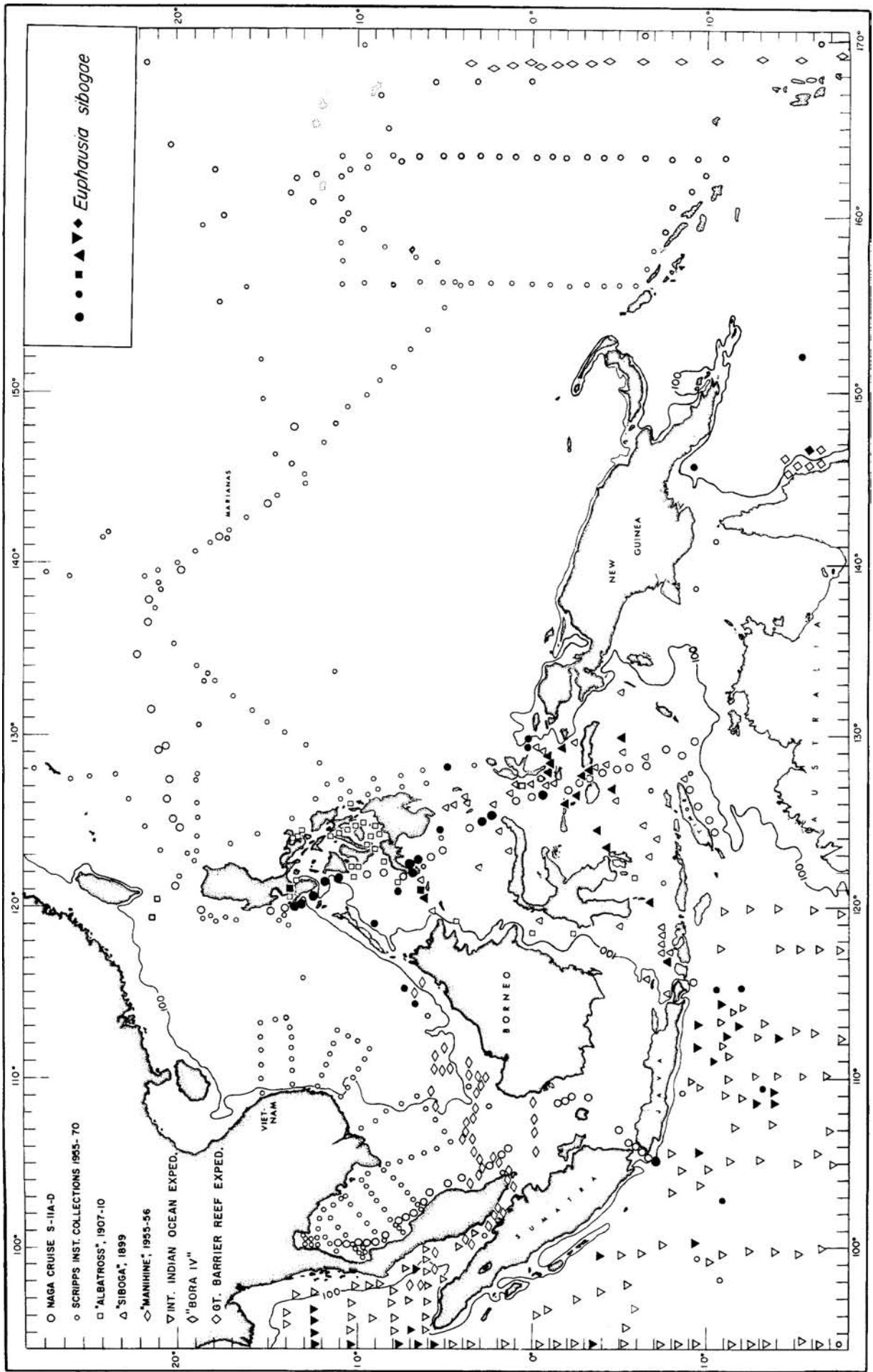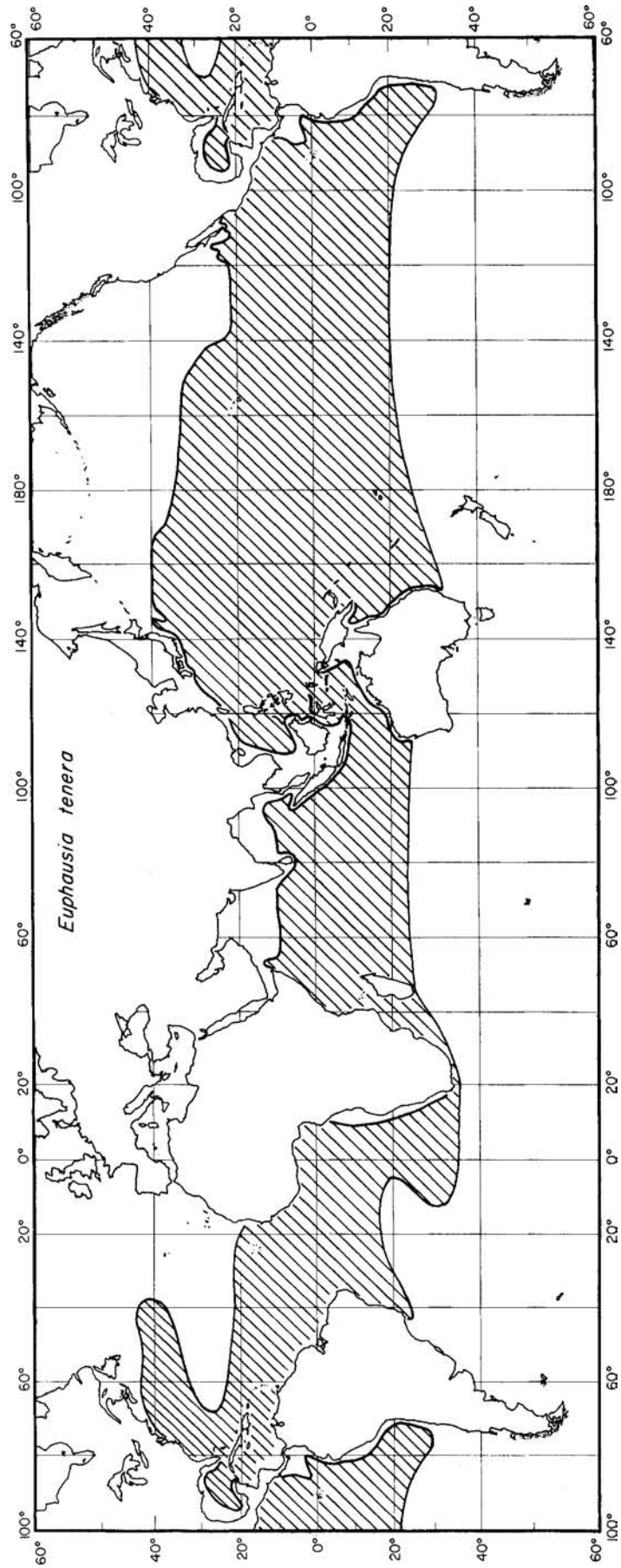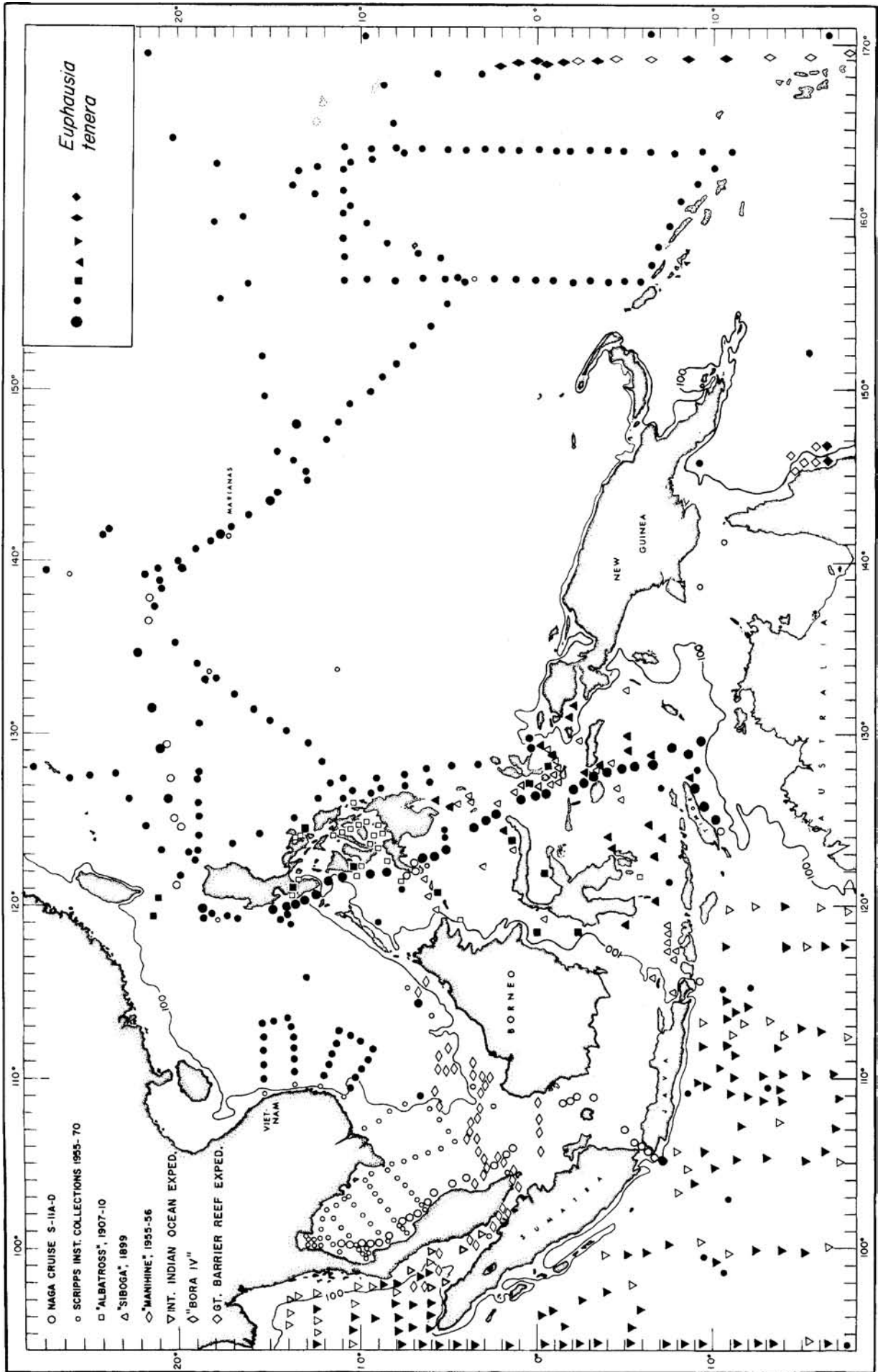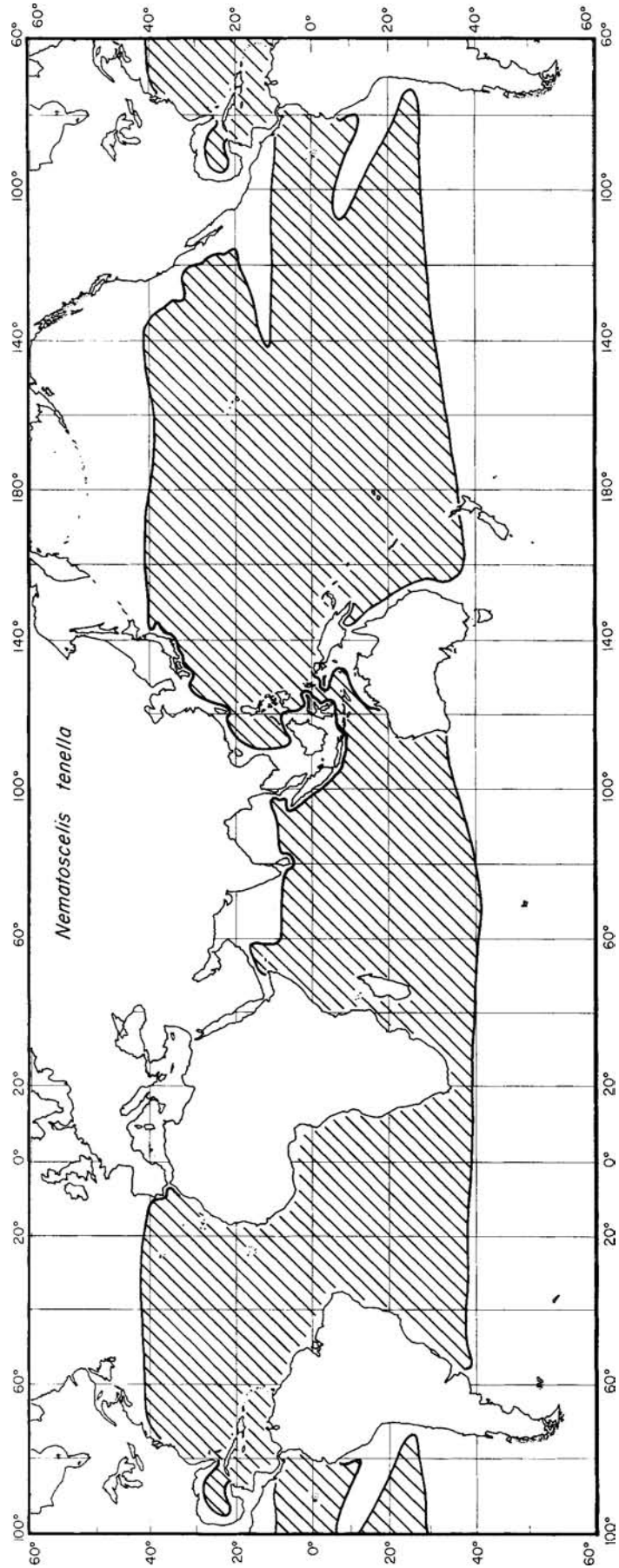
Figure 60a.

Figure 60b.

111

Figure 61a,b.

112

Figure 61c.

Figure 62a.

114

Figure 62b.

115

Nematobrachion flexipes

Figure 63a.

Nematobrachion sexspinosus

Figure 63b.

Figure 63a,b.

116

Figure 63c.

Figure 64a.

Nematobrachion boöpis

118

Figure 64b.

Stylocheiron carinatum

Figure 65a.

Figure 65b.

Stylocheiron suhmii

Figure 66a.

122

Figure 66b.

Stylocheiron suhmii

Figure 67a.

124

Figure 67b.

125

Figure 68a.

126

Figure 68b.

127

Stylocheiron affine INDO - AUSTRALIAN FORM

Figure 69a.

Figure 69b.

129

Stylocheiron affine CENTRAL FORM

Figure 70a.

130

Figure 70b.

Stylocheiron microphthalma

Figure 71a.

Figure 71b.

Stylocheiron
microphthalma

○ ● ■ ▲ ▼ ◆

○ NAGA CRUISE S-IIA-D
○ SCRIPPS INST. COLLECTIONS 1955-70
□ "ALBATROSS", 1907-10
△ "SIBOGA", 1899
◇ "MANIHINE", 1955-56
▽ INT. INDIAN OCEAN EXPED.
▷ "BORA IV"
◇ GT. BARRIER REEF EXPED.

133

Figure 72a.

Stylocheiron elongatum

134

Figure 72b.

135

Figure 73a.

136

Figure 73b.

*Stylocheiron
longicorne*

○ NAGA CRUISE S–IIA–D
○ SCRIPPS INST. COLLECTIONS 1955–70
□ "ALBATROSS", 1907–10
△ "SIBOGA", 1899
◇ "MANIHINE", 1955–56
▽ INT. INDIAN OCEAN EXPED.
◊ "BORA IV"
◇ GT. BARRIER REEF EXPED.

NEW
GUINEA

BORNEO

VIET-
NAM

SUMATRA

MARIANAS

AUSTRALIA

137

Stylocheiron maximum

Figure 74a.

138

Figure 74b.

Stylocheiron abbreviatum

Figure 75a.

Stylocheiron robustum

Figure 75b.

140

Figure 75c.

141

Mediterranean Sea euphausiids evidently do not communicate through the Suez Canal (Weigmann, 1974b), the species in the Red Sea being of the Indo-Pacific fauna while those in the Mediterranean are subtropical pan-oceanic species and Atlantic endemics.

The Indo-Australian Archipelago. This is the only low latitude inter-ocean connection. The Molucca-Banda-Timor Sea waterway is clearly utilized today by the species of Group I above (including warm-water cosmopolites and Indo-Pacific equatorial species), and by widely ranging mesopelagic species of Group II.

Subtropical species associated with the central water masses are found to differing degrees in the inter-ocean seas. These differences are diagrammed in figures 76-78. In both *Euphausia brevis* (Fig. 76a) and *Stylocheiron suhmii* (Fig. 76b) the Pacific population is separated by the Archipelago from that of the Indian Ocean. *E. brevis* scarcely enters the South China Sea, whereas *S. suhmii* is regularly present there, though in low density. Both extend southwestward from the North Pacific, as far as the western edge of the Celebes Sea. There the distributions break. Neither has been found in the Timor Sea, at the southern limit of the inter-ocean route.

Rare or inconsistent occurrence in these seas of certain other species indicates the possibility of either recent or incipient communication between the populations of the two oceans. For example, certain species have appeared in samples from the Banda or Timor Seas, but irregularly, so as to suggest transient or "puddle jumping" east-west communication of genetic material. *Thysanopoda astylata* (Fig. 77a) appeared in the Banda Sea, though not elsewhere in waters of the Archipelago. *Stylocheiron microphthalma* (Fig. 77b) was inconsistent in occurrence and in low density in the inter-ocean basins, suggesting the possibility of fragmented distributions there of even those species associated solely with the Indo-Pacific equatorial region.

The distribution of the *Nematoscelis atlantica-N. lobata* species pair (Fig. 78a) demonstrates what appears to have been a case of local speciation. *N. atlantica*, a present-day central water mass species, may be presumed to have occurred across the Indo-Australian seas at the time that its all-ocean distribution was established. Subsequent retraction from the tropics left residual pockets of distribution near the Philippines. These pockets of the *N. lobata* precursor were able to adapt to the local evolving environment. The highly modified structure of the petasma of *N. lobata* suggests (as with *E. gibba*, discussed below) that there was at least intermittent mating interaction between the members of the sibling pair early in their differentiation. Alternatively, the interaction might have taken place between *N. lobata* and a presently sympatric species, e.g. *N. microps*. This led to intensified selection for reproductive isolation (see taxonomic description of *N. lobata*). Interaction between sibling species leading to strong differentiation of secondary sexual characters has been observed in planktonic animals, for example, by Fleminger (1967) in the case of calanoid copepods of the genus *Labidocera*.

The limited distribution of *Stylocheiron insulare* (Fig. 78b), though not as narrow as that of *N. lobata*, suggests a similar origin. Geographical and climatological diversity among the seas of the Archipelago appears to have enhanced the possibilities for local adaptation of surviving segments of a once broader distributional range. In addition, the oceanic current systems to the east and west of the archipelago both provide constant transport to the region from subtropical latitudes. Selection favoring adaptation for local survival of incoming elements of these species is doubtless constant here, as elsewhere.

The relationship of *S. insulare* to any particular other species in the "S. longicorne group" is not clear. Evidently its origin is not recent. The same is apparently true with *S. indicus* (Fig. 67), a species even more morphologically distinct from other members of the "S. longicorne group" than *S. insulare*.

Euphausia sibogae and *E. sanzoi-E. fallax* occupy the Indo-Australian seas. Each is closely related to a species living in the Eastern Tropical Pacific, *E. sibogae* to *E. distinguenda* (Fig. 58a) and *E. sanzoi* and *E. fallax* to *E. gibboides* (Fig. 56a).

The differentiation of the individual species, discussed in Brinton (1962a), appears related to the contraction and fragmentation of once-continuous distributions across the tropical
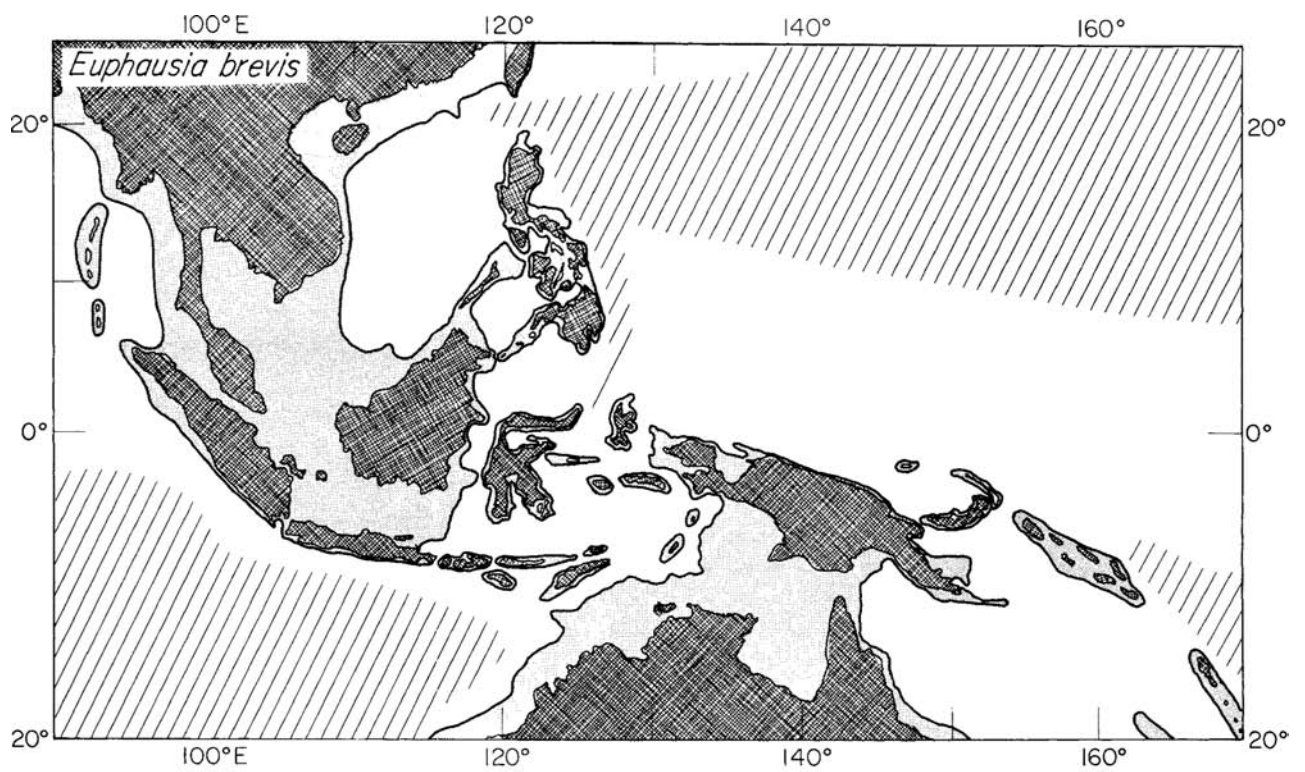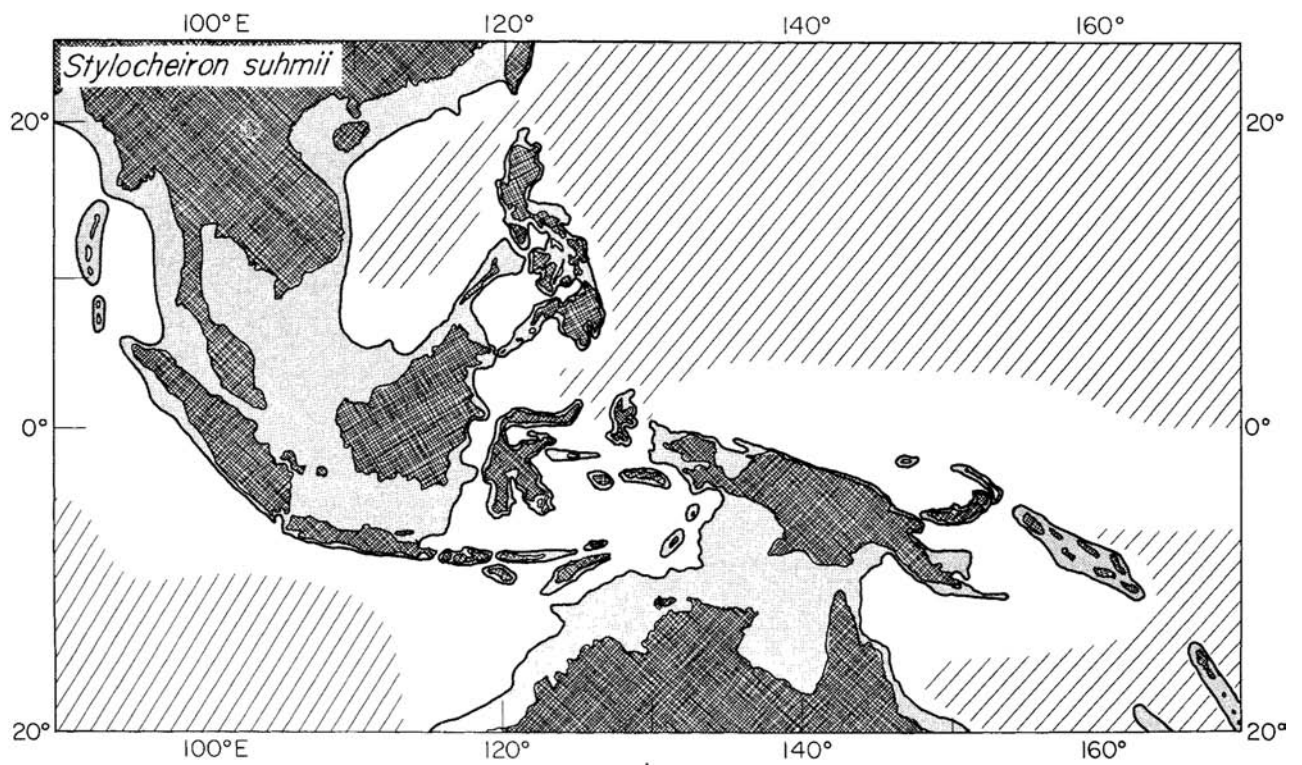
Figure 76. Inter-ocean seas as barrier to "Central water mass species" a) *Euphausia brevis*, b) *Stylocheiron suhmii*, digrammatic.

143
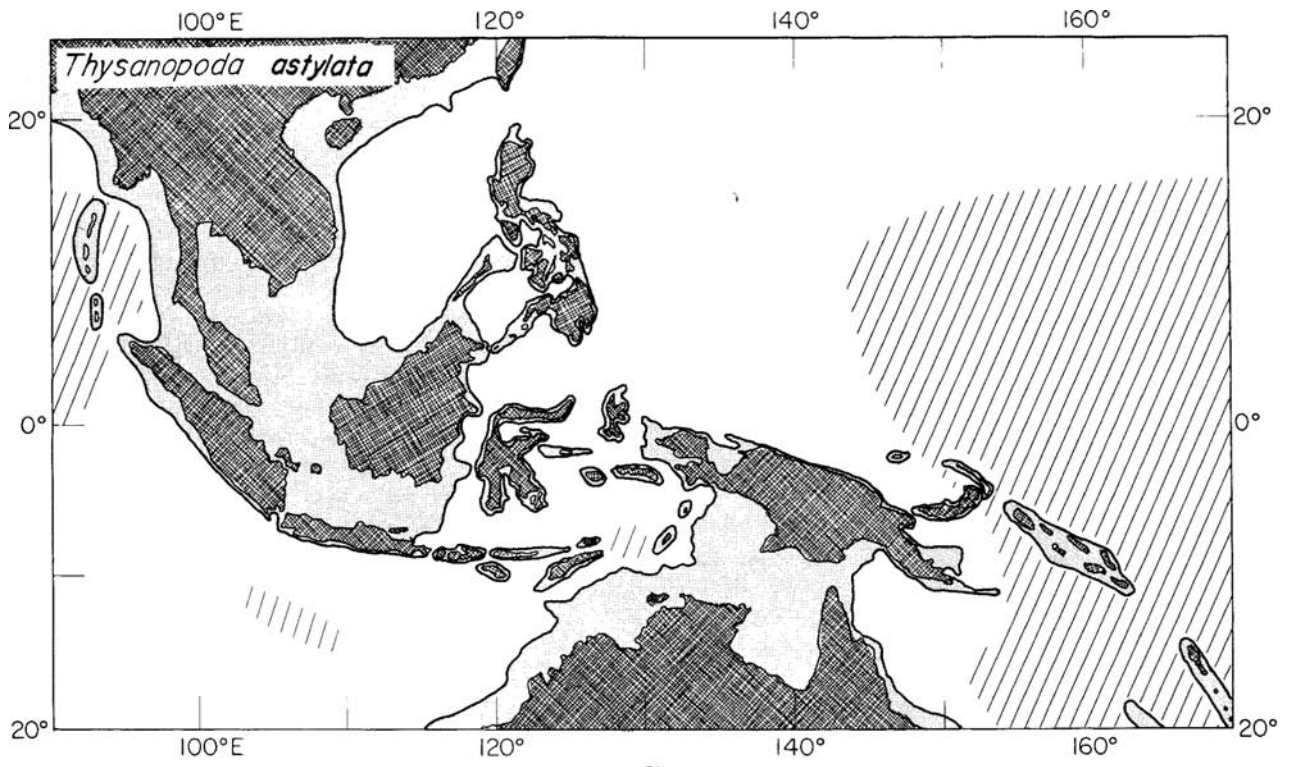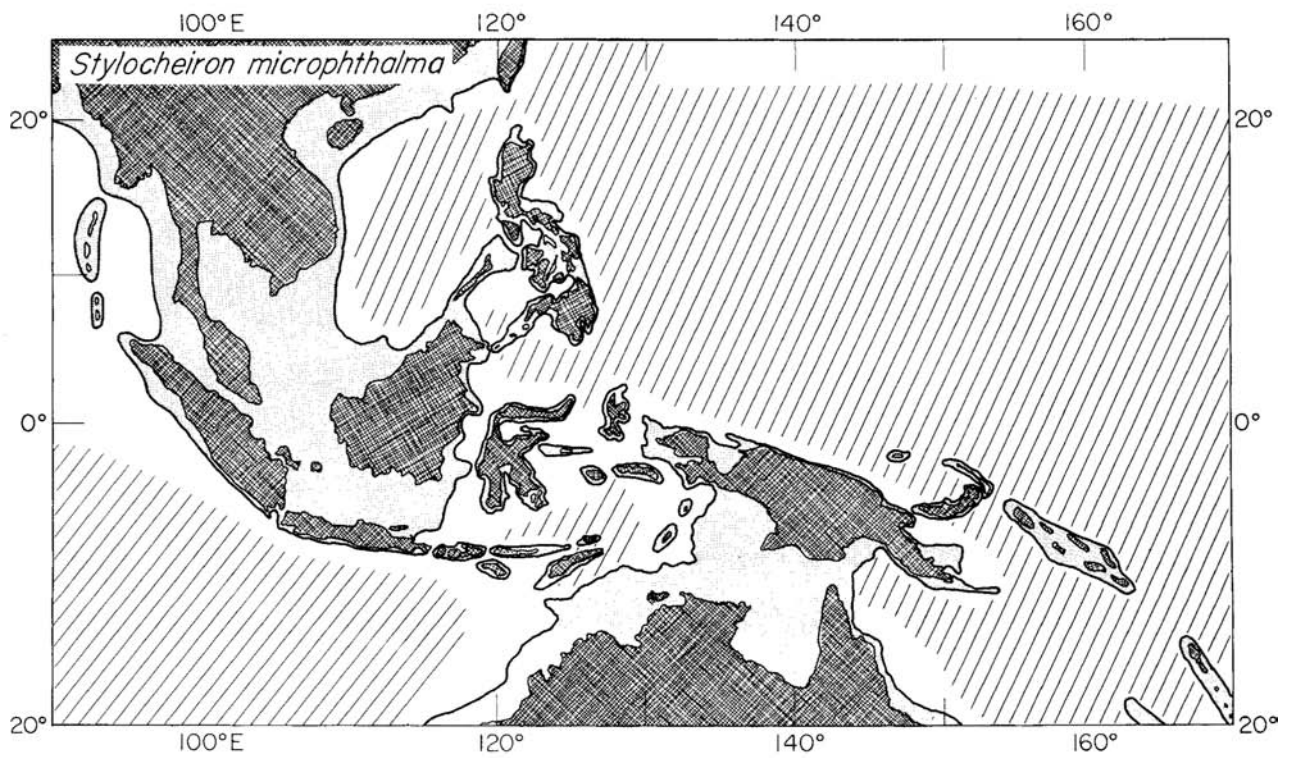
Figure 77. Inter-ocean "puddle jumps" in distributions of a) *Thysanopoda astylata*, b) *Stylocheiron microphthalma*. digrammatic.
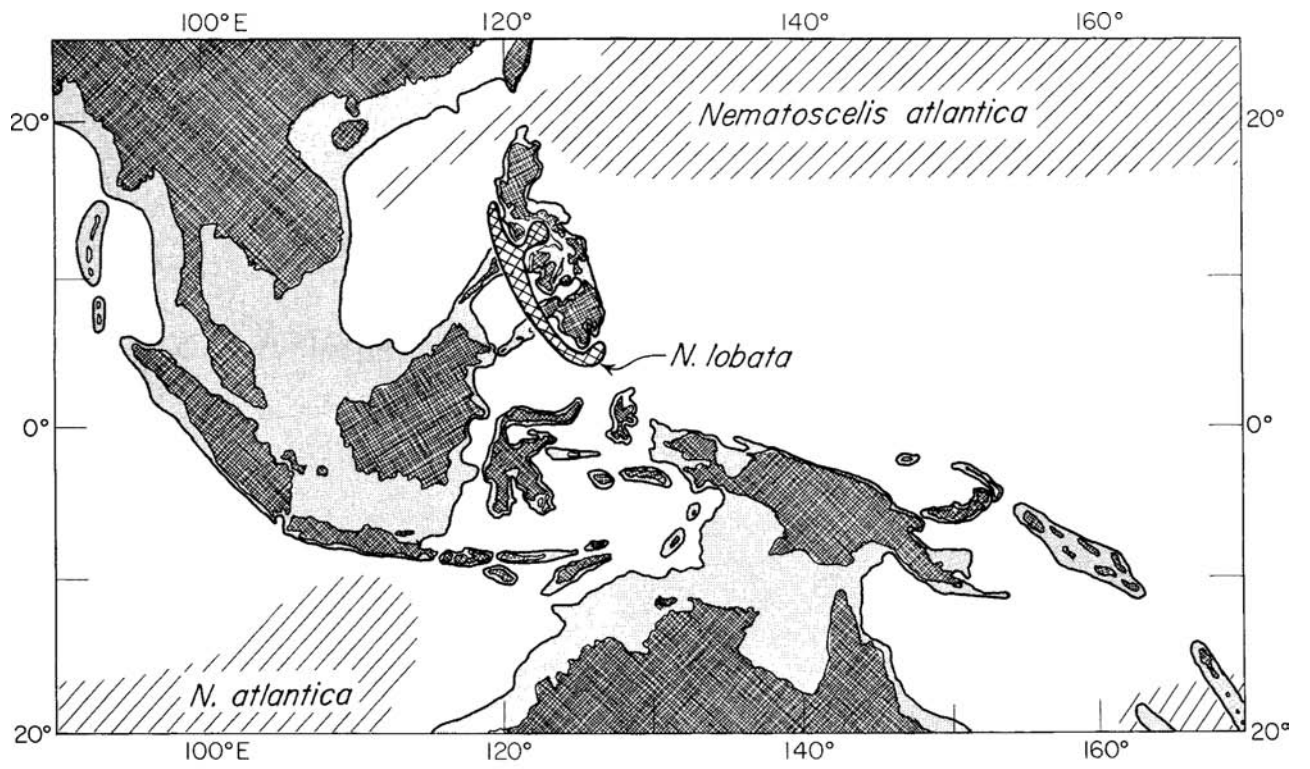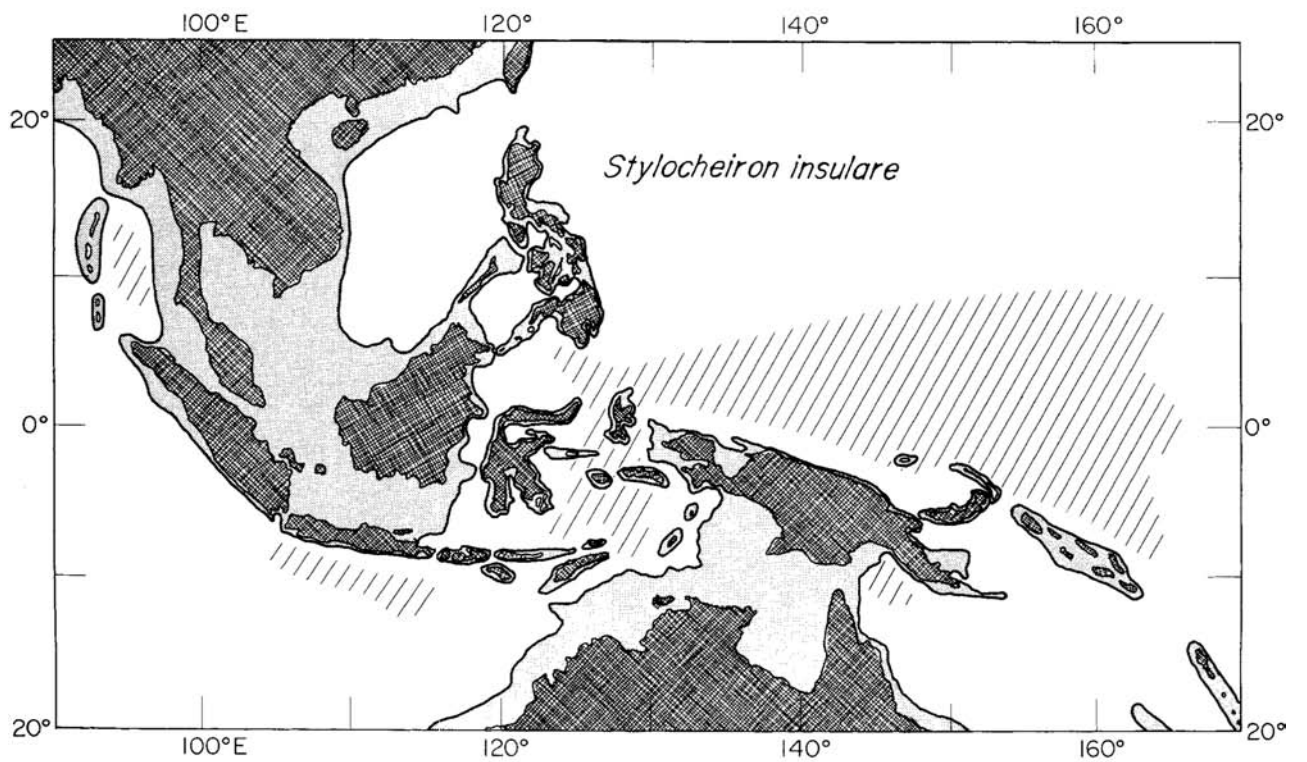
Figure 78. a) The central species *Nematoscelis atlantica* and Southeast Asian species *N. lobata*, and b) the fragmented range of the Southeast Asian species *Stylocheiron insulare*, diagrammatic.

Indo-Pacific Oceans.

E. sibogae and *E. distinguenda* are very similar morphologically today (see taxonomic discussion) and may or may not consist of specifically differentiated genetic pools. *E. distinguenda* extends westward to the mid-Pacific (175° W) along a productive thermal anticline at the southern edge of the North Equatorial Current. This is a narrow extension of the productive Eastern Tropical Pacific region inhabited by this species. In the Indian Ocean *E. sibogae* is abundant in the productive North Indian Ocean and sparse but widely scattered in the region of the Archipelago. As was noted in an earlier section, the patches of distribution around the Archipelago may or may not be presently connected with each other. *E. distinguenda-sibogae* appears to represent incipient speciation in a complex adapted to highly productive tropical waters. There, they tolerate, in the course of their diel vertical migrations, a subsurface layer in which oxygen is intensely diminished (Brinton, in press), an adaptation not general to euphausiids (Teal and Carey, 1967). The occurrence of *E. sibogae* in the Archipelago in a less than optimal habitat may be sustained by local productive localities in the basins and south of Java. There may also be intermittent recruitment from the east and west, not evident in the distributional chart.

Euphausia sanzoi and *E. fallax* are patchy in the Indo-Australian region. The existence there of two species of the "E. gibboides group" implies that an Indo-West Pacific population was partitioned, yielding separate eastern and western segments which have now undergone substantial differentiation. Both species appear most abundant in regions of productive slope waters – *E. sanzoi* in the Somali Current and Arabian Sea, the South China Sea, and near the New Hebrides, and *E. fallax* in the Andaman Sea and near the Philippines. A single calyptopis larva of the *E. fallax* type was found in a sample from just south of Ceylon and in a sample from just north of Madagascar (Knight, MS). These records are shown in figure 56a. *E. fallax* in the Coral Sea is based on 7-8 mm juveniles not possessing the abdominal spine of *E. sanzoi*. The co-occurrence of the two species in large numbers in the same samples from the Philippines (see taxonomic discussion) suggests a recent re-invasion of that region by one or the other of the two.

A calyptopis larva, recognized by Knight (MS) as *E. gibboides*, was found at 11° S, 164° E north of the New Hebrides, in a region occupied by *E. sanzoi*. This is 3000 km west of the previously known limit of *E. gibboides*. Such extreme expatriotism is rare, but the occurrence is within the regime of the westerly South Equatorial Current, a pathway along which an *E. fallax-sanzoi* precursor may reasonably be supposed to have crossed the Pacific from the eastern waters now occupied by *E. gibboides*. (Also, see discussion of *E. similis-E. gibboides*, in "The South Australian Barrier", below.)

The South African Barrier. Presence of a species in waters off the Cape of Good Hope – a feature of most of the distributions considered here – demonstrates a mechanism for inter-ocean transport for even the equatorial species (e.g. *E. paragibba*, Fig. 57b, c). These species utilize the nearshore Agulhas Current for the southerly extension of their ranges on the Indian Ocean side of Africa. However, to the west of South Africa a different water mass is encountered. This derives from the easterly West Wind Drift. It bends northward toward the coast to initiate the cool northerly Benguela Current system in which coastal temperatures are 15-16° C year-round. There is continuity of 20° C surface water between the two oceans in the summer, dropping to 15° C in the winter. There is year-round continuity of 12° C water at a depth of 200 m (Sverdrup, Johnson, and Fleming, 1942). This appears to be within the range of tolerance of tropical-subtropical species not extending as far south as the West Wind Drift, permitting injections of the Indian Ocean populations into the Atlantic, e.g. *Thysanopoda tricuspidata* (Fig. 45a), *T. monacantha* (Fig. 47a).

The subtropical-temperate species of the southern hemisphere are able to utilize the West Wind Drift as well as the Agulhas Current (e.g. *Euphausia hemigibba*, Fig. 57a) as compared with one-way transport in *T. tricuspidata*.

In general, the species closely bound to the equatorial zone (i.e. the Indo-Pacific group consisting of *Euphausia diomedeae*, Fig. 54b, *E. paragibba*, Fig. 57b, *E. sibogae-distinguenda*, Fig. 58,

Nematoscelis gracilis, Fig. 61b, and *Stylocheiron microphthalma* Fig. 71) have not colonized the Atlantic. Factors other than transport-access apparently are responsible. Colonization of the Atlantic by *E. diomedeae* may be inhibited there by *E. americana*, a species grossly resembling *E. diomedeae* and occupying the Atlantic part of the circumglobal tropical belt. Similarly, *N. gracilis* and *S. microphthalma* of the Indo-Pacific are absent in the tropical Atlantic where respective congeners *N. atlantica* and *S. suhmii* (Figs. 62a, 66a) occur. But unlike *E. americana*, these species (*N. atlantica, S. suhmii*) are not endemic to the tropical Atlantic. Both live also in subtropical parts of the Atlantic, Pacific and Indian oceans, but do not co-occur with tropical *N. gracilis* and *S. microphthalma* in the two latter oceans. Thus only in the Atlantic do *N. atlantica* and *S. suhmii* range through the tropics, their presence there perhaps having prevented successful invasions from the Indo-Pacific by *N. gracilis* and *S. microphthalma*. Conversely, occupancy of the Indo-Pacific tropics by the latter may exclude *N. atlantica* and *S. suhmii* from there. However, the concurrence of habitats of *N. gracilis* and *S. microphthalma* with equatorial water masses makes this appear the less likely.

On the other hand a central species, *Euphausia hemigibba* (Fig. 57a), appears not to extend across the tropics in the Atlantic, being restricted there to mid-latitudes in both hemispheres. Instead, the "E. gibba group" is represented in the tropical Atlantic by *E. pseudogibba*, a species which shares the tropical Indo-Pacific region with *E. paragibba*. There their areas of occurrence are adjacent and mutually exclusive. The presence of *E. pseudogibba* rather than *E. paragibba* in the tropical Atlantic is surprising, because only the latter has access to South African waters at the present time. But it is consistent with the absence from the Atlantic of all species bound closely to the Indo-Pacific equatorial zone.

The South Australian Barrier. Waters south of Australia are not inhabited by "central water mass species" of the Pacific and Indian Oceans, except by those considered marginal to that assemblage. *Euphausia recurva* (Fig. 54) is such a species, achieving maximum numbers in regions where central waters impinge upon cooler, more productive boundary currents (Brinton, 1962a). In this context, the West Wind Drift may be considered a boundary current. Other subtropical species must presently rely upon the Indo-Australian seas for the possibility of retaining genetic homogeneity within the overall Indo-Pacific population.

The two species *Euphausia similis* (Fig. 55) and *E. gibboides* (Fig. 56) may also be considered in relation to transport south of Australia. Both are large species, the adults of which live somewhat deeper than most of the species under consideration here, their upper limit of range being within the thermocline. While grossly similar morphologically (body size, large eye, antennular peduncle, abdominal armature), they appear not to be closely related (see taxonomic discussion). Within the system of circulation bounding the warm-water regimes of the oceans, their ranges are almost mutually exclusive. *E. similis* is circumglobal in the southern hemisphere. This distribution is along a path almost certainly occupied by *E. gibboides* at one time, if we are to account for the fact that the Atlantic and Pacific populations of this species appear to be morphologically indistinquishable. (*E. sanzoi* and *E. fallax*, it was argued above, could have derived from *E. gibboides* or its precursor as a consequence of early westward transport along the tropical Pacific across the East Pacific barrier, rather than from isolation in the Indian Ocean of a segment of a once circumglobal population of "E. gibboides" in the southern hemisphere.) *E. gibboides* is lacking, today, in the Indian Ocean and the West Wind Drift. Both areas are occupied by *E. similis*, which appears to have geographical continuity among all of its populations, however tenuous this may be along the north-south path through the Indo-Australian Archipelago and the Indian Ocean.

The dense localized population of *E. similis* south of Japan (this species' most northern habitat, Nemoto, 1959; Brinton, 1962a) contrasts with the low densities observed elsewhere, including the West Wind Drift. With respect to its capacity to sustain high productivity of a large euphausiid species oriented to thermocline or upwelling-zone feeding, the south Japan habitat of *E. similis* corresponds with the southern California slope region in which *E. gibboides* is abundant. Both

species appear in transitional regions between warm-temperate and subtropical waters. They are least dense away from the continents – *E. gibboides* in the North Pacific Drift and *E. similis* in the West Wind Drift of the southern hemisphere.

Southern Australian waters were undoubtedly accessible to subtropical species during relatively recent times of presumed warmer global climate. During such times transport could have been from east-to-west immediately south of Tasmania (44° S) and Australia, or west-to-east in the broader oceanic wind drift to the south. The endemism of *Euphausia gibba* in the central South Pacific may have been established through the following events: 1) isolation from other central water masses of a South Pacific central segment of the broadly ranging "E. gibba group" precursor; 2) partial morphological differentiation of the South Pacific population (*E. gibba*); 3) reinvasion of the South Pacific by central populations (*E. hemigibba*) from the Indian Ocean by the route south of Australia, or from the North Pacific by means of transport across the tropics in the western Pacific; 4) biological interaction between these two precursors of present species, resulting in the extreme petasma modifications now found in *E. gibba* (through character displacement by means of selection favoring single-species mating by each sibling species); 5) elimination (or recession) of *E. hemigibba* from the South Pacific.

The South American Barrier. Of the species that are marginally subtropical, only *E. similis* occurs at sufficiently high latitudes (57° S) to have access to Drake's Passage, south of Cape Horn. Some widely ranging mesopelagic species also appear to be circumglobal in distribution, or so nearly so that transport south of South America may be considered possible at the present time (e.g. *Nematobrachion boöpis*, Fig. 64, *Stylocheiron maximum*, Fig. 74).

Thus, South America has probably long been a barrier to east-west connections among subtropical populations, the present patterns of the species distributions having developed as a consequence of multiple invasion, recessions, isolations and population interactions at lower latitudes.

Table 4

NUMBER OF EUPHAUSIID SPECIES IN SOUTHEAST ASIAN WATERS IN RELATION TO TOTAL KNOWN SPECIES, BY GENUS

Genus	Species in Genus	Species in S.E. Asian Waters
Bentheuphausia	1	1
Thysanopoda	13	10
Meganyctiphanes	1	0
Nyctiphanes	4	0
Thysanoessa	10	0
Pseudeuphausia	2	2
Euphausia	31	13
Tessarabrachion	1	0
Nematoscelis	7	5
Nematobrachion	3	3
Stylocheiron	11	11
	84	45

SECTION III. THE SOUTHEAST ASIAN SPECIES: CLASSIFICATION, KEYS, DESCRIPTIONS

GENERAL

Euphausiaceans are shrimp-like swimming crustaceans. The adult size of most species falls in the range of 10–30 mm body length. The smaller species are regarded as members of the plankton and the larger as micronekton. There are both neritic and oceanic species, the bulk being oceanic. Among the latter, there are epipelagic species (0-ca. 400 m depth), mesopelagic (ca. 200–700m) and bathypelagic species (ca. 700–2000m). The bathypelagics are few, but attain lengths up to 150 mm.

The Euphausiacea together with the Decapoda comprise the subclass Eucarida, possessing a carapace fused with all thoracic segments, a short heart in the thorax, a large branched digestive organ, the hepatopancreas, and lacking oostegites (ventral plates forming the brood pouch of peracarids). Characteristics of the Euphausiacea are as follows: gills are exposed specialized podobranches, exopodite of maxilla is small, complex moveable photophores are present, mode of larval development is distinctive.

Some carcinologists, notably Calman (1905), Kemp (unpublished), Gurney (1942) and Gordon (1955b) believed that there was justification for incorporating euphausiids into the lower Decapoda. They noted similarities to certain Penaeidea, particularly the Sergestidae, including the presence of photophores, the reduction of posterior thoracic limbs accompanying the axial compression or reduction of those thoracic segments, and the presence of a free nauplius larva. These arguments are summarized in Mauchline and Fisher (1969). Brinton (1966) theorized that the similarities of euphausiids to sergestids were a consequence of independent adaptations to similar pelagic habitats.

Gordon (1955a) called attention to the importance of larval characteristics in classification, a concept which is being progressively implemented in euphausiids as details of larval development become better understood (e.g., Gopalakrishnan, 1973a; Knight, 1973, 1975). It is employed in some of the ensuing classifications of species.

Following Colosi (1917) the Order Euphausiacea is divided into the families Bentheuphausiidae, with *Bentheuphausia*, and Euphausiidae, with all other (10) genera. Colosi's further attempt at subdivision of the Euphausiidae into four subfamilies does not appear to have yielded natural groupings and is not retained.

The most comprehensive descriptions of euphausiid species are contained in a small number of monographs and papers, the majority of which have a regional emphasis:

> Southeast Asia. Hansen (1910).
>
> Tropical and southeastern Pacific. Hansen (1912); Antezana (in press).
>
> North Pacific. Banner (1949); Boden, Johnson and Brinton (1955).
>
> Antarctic and subantarctic *Euphausia*. John (1936).
>
> Temperate North Atlantic. Einarsson (1945).
>
> Eastern North Atlantic and Mediterranean. Hansen (1905a, b), Ruud (1936).
>
> Genus *Thysanoessa*, world basis. Nemoto (1966).
>
> Genus *Nematoscelis*, world basis. Gopalakrishnan (1974).
>
> *Stylocheiron affine* and *S. longicorne* "forms", and bathypelagic *Thysanopoda*. Brinton (1962a).

This report focuses on Indo-Pacific species, particularly on those in the tropical seas connecting the two oceans. In so doing, it includes taxonomic and biological information on 45 of the 84 known euphausiid species, and 7 of the 11 genera (Table 4). Omitted, except where referred to for comparative purposes, are the 38 species not occurring in the region:

1) the two *Thysanopoda* species related to *T. orientalis: T. acutifrons* and *T. microphthalma* (see Hansen, 1910, and Einarsson, 1945).

2) monotypic *Meganyctiphanes norvegica* (see Einarsson, 1945), of the North Atlantic.

3) the four *Nyctiphanes* species, all coastal, called "reproductive stenotherms" by Hedgpeth (1957), see Hansen (1911). In addition, for *N. couchii*, see Einarsson (1945); for *N. capensis*, see Boden (1954, 1955), Meira (1970); for *N. simplex*, see Hansen (1912), Boden et al. (1955), Antezana (in press); for *N. australis*, see Hansen (1912).

4) three eastern-Pacific *Euphausia* species related to *E. sibogae: E. distinguenda, E. lamelligera* and *E. mucronata* (see Hansen, 1912, and Antezana, in press).

5) *Euphausia pacifica* and *E. nana* (see Brinton, 1962b) of the North Pacific.

6) nine antarctic or subantarctic *Euphausia* species dealt with by John (1936): *E. superba, E. lucens, E. crystallorophias, E. frigida, E. vallentini, E. spinfera, E. triacantha, E. longirostris*, and *E. hanseni* (west coast of Africa).

7) 3 species with pectinate (comb-like) lappet on 1st antennular segment: *Euphausia eximia* of the eastern Pacific (see Hansen, 1912) and *E. krohnii* and *E. americana* of the Atlantic (see Hansen, 1911).

8) the 10 *Thysanoessa* species, primarily a genus of temperate latitudes: *T. macrura, T. vicina, T. gregaria, T. parva, T. longipes, T. inspinata, T. spinifera, T. longicaudata, T. raschii, T. inermis* (see Einarsson, 1945; Banner, 1949; Nemoto, 1966).

9) two *Nematoscelis* species, *N. difficilis* and *N. megalops*, both of mid-latitudes (see Gopalakrishnan, 1974, in press).

10) monotypic *Tessarabrachion oculatum* of the subarctic North Pacific (see Hansen, 1915).

THE TAXONOMIC CHARACTERS, FORM AND FUNCTION

Usefulness of a taxonomic character depends upon how conspicuous and/or consistent it is. The general form and development of thoracic legs are of generic importance but are infrequently used in the identification of euphausiids because 1) characteristically modified anterior legs are often elongate and easily broken off, and rudimentary posterior legs, though present, may be obscure, or 2) the genus or sub-generic group is usually determinable on the basis of more obvious specialized characters such as shape of eye, antennular peduncle, rostrum and carapace keel. Details of such structures are specific criteria in most genera.

The petasma of the male provides reliable ultimate characters, except in *Thysanoessa* and *Stylocheiron* where the organ is minute and particularly difficult to prepare for examination in a standard position. The petasma consists of a complex of hooks and processes, some of which appear to be sensory and/or secretory with surfaces bearing numerous papillae visible under high (600x) magnification. It is hypothesized that these are used in preparing or stimulating the appropriate female for implantation of the spermatophore and ovulation, rather than in mechanical transfer and manipulation of the spermatophore as has been supposed. The petasma has been ambiguously designated "copulatory organ".

Antennular peduncles, frequently species specific but also sexually dimorphic in many species, appear to contain glandular bodies (easily seen in *Nematoscelis* peduncular segments) and bear clusters of aesthetascs — hollow colorless hairs of presumed chemo-sensory function —

conspicuously in *Bentheuphausia, Thysanopoda* and *Stylocheiron*. This indicates a chemosensory role for the antennular structures, the species-specific characteristics functioning to conserve reproductive as well as food-seeking energy by making possible mutual recognition of con-specific individuals seeking to school or mate. Thus taxonomic importance of a structure implies biological importance.

Eye size and shape is presumed to be related to habitat adaptation, including feeding specificity, depth positioning, and avoidance of predators. For example, co-occurring species of the "Stylocheiron longicorne group" are centered at progressively greater depths in the sequence *S. suhmii, S. affine, S. longicorne, S. elongatum* (Brinton, 1967; Baker, 1970), the greater the depth the greater the number (species-specific) of facets in the upper lobe of the eye. Rostrum, carapace keels and denticles, and abdominal armature appear to function as structural strengtheners and in protective roles.

Structures providing taxonomic characters, listed below by genus, are considered primary or secondary on the basis of their relative usefulness to the biologist in determining the species.

Thysanopoda.	Primary: peduncle of 1st antenna (useful except with siblings: *acutifrons-orientalis-microphthalma* and *aequalis-astylata*); petasma; rostrum-frontal plate.
	Secondary (useful in relatively few species): abdominal armature.
Euphausia.	Primary: Peduncle of 1st antenna (except in "E. gibba group"); petasma.
	Secondary: rostrum; abdominal armature; eye size, pigmentation.
Nematoscelis.	Primary: rostrum; dorsal carapace keel; petasma.
	Secondary: eye size, shape; distal part of 1st thoracic leg; body size, proportions.
Nematobrachion.	Primary: abdominal armature; antennular peduncle; frontal plate; petasma.
Stylocheiron.	Primary: eye shape and structure; body proportions.
	Secondary: petasma, spination of elongate 3rd thoracic leg (both reliable among species groups only).

Two major genera are not within the geographical scope of this report. The species of *Nyctiphanes* are narrowly separated morphologically though widely separated geographically; petasma and antennular peduncle structure are considered species-specific. The species of *Thysanoessa* are narrowly separated both morphologically and geographically; antennular peduncle, eye, and abdominal armature provide generally useful characters, while petasma and elongate 2nd thoracic leg are less reliable.

THE FAMILIES OF THE ORDER EUPHAUSIACEA

Family Bentheuphausiidae Colosi, 1917

In male, endopodites of first pair of pleopods not modified as petasmas (copulatory organs). Basipodite of first pair of pleopods carries 1–6 spines. Endopodite of maxillule is two jointed. Endopodite of maxilla is three jointed. Outer uropod has a sub-distal transverse suture. There are no photophores. Eyes reduced in size and pigment. All eight thoracic legs well developed.

Family Euphausiidae Holt and Tattersall, 1905

In male, endopodites of first pair of pleopods are modified as petasmas. Basipodite of first pair of pleopods has no spines. Endopodites of maxillule and maxilla are single jointed. Outer plates of uropods have no transverse suture. Photophores present on eye stalks, sides of thorax, and ventral side of abdomen. Eyes well developed and black in fresh specimens. Last or penultimate and last pair of thoracic legs are rudimentary.
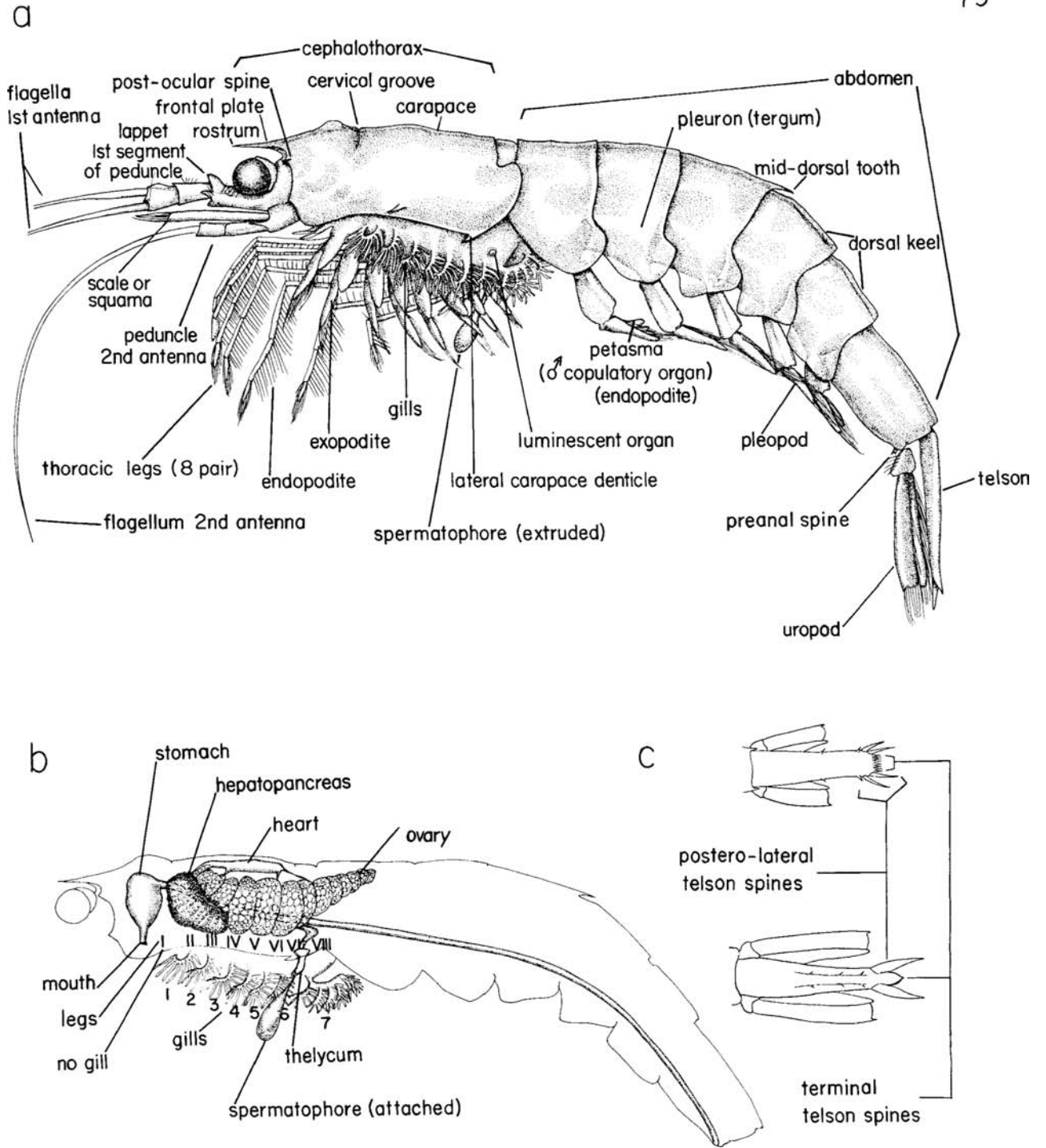
Figure 79. a) Morphology of generalized euphausiid, male (spermatophore extruded). b) anatomy of female (spermatophore attached). c) telsons, uropods (dorsal view) showing spination in an early furcilia larva and a juvenile (both *Thysanopoda egregia*).

DESCRIPTIONS OF THE SPECIES

Family BENTHEUPHAUSIIDAE

Genus *Bentheuphausia* G. O. Sars, 1885

Bentheuphausia amblyops G. O. Sars, 1885

Fig. 80

Thysanopoda (?) *amblyops*, G. O. Sars, 1883: 23; *Bentheuphausia amblyops* G. O. Sars, 1885: 109–114, fig. 4, pl. xix; Einarsson, 1942; 263–285, figs. 13–16; Boden et al., 1955: 294–295, fig. 5.

The foregoing characteristics of the family Bentheuphausidae are based upon this species alone. Its appearance differs strikingly from that of other euphausiids. Fresh specimens are a deep red color, except for the gills, grossly resembling elements of the mysid and decapod bathypelagic fauna.

Eye: Small, reddish-brown, facets imperfectly developed, coincident with absence of photophores.

Antennular peduncle: Stout or massive, first two segments being high, with dorsal portions each extended forward as plates appearing to reinforce the successive joints of peduncle; two distal segments somewhat thicker in male than female.

Carapace: Frontal plate oblique and rostral process a short, scarcely acute triangle extending forward to mid-point of eye. There are no lateral denticles in the adult. In young specimens of about 10–15 mm length the posterolateral margin is serrated.

Abdomen: Uniform and symmetrical, without keels. Endopod of 1st pleopod not modified as petasma in male, but basipodite carries 1–6 spines. 6th segment short, 1.3 times longer than deep.

Length: 25–50 mm.

Family EUPHAUSIIDAE

Key to the Genera

1a. Thoracic legs with none of endopodites extremely elongate. Eye spherical or ovoid.

2a. 8th leg with endopodite rudimentary.

3a. 7th leg of same appearance as 6th. *Thysanopoda* Milne-Edwards

3b. 7th leg with endopodite of not more than 2 segments, but which are elongated so that leg appears not much shorter than 6th.

4a. 6th and 7th legs with exopodites in both sexes. Terminal and proximal processes of petasma both developed. *Meganyctiphanes* Holt and Tattersall

4b. 6th and 7th legs with no exopodites in female. Terminal and proximal processes of petasma both lacking. *Nyctiphanes* G. O. Sars

4c. 7th leg with fully developed exopodite, but with no endopodite in male and with short, unjointed or two-jointed endopodite in female. *Thysanoessa* Brandt (in part): *(T. raschii, T. inermis, T. spinfera)*

2b. 7th and 8th legs with endopodites quite rudimentary.

5a. 6th leg with distal three segments of endopodite greatly reduced. *Pseudeuphausia* Hansen

5b. 6th leg with endopodite similar in appearance to 5th. *Euphausia* Dana

1b. Thoracic legs with endopodites unequally developed, with 2nd, or 3rd, or both greatly elongated. Eye higher than broad, with distinct upper and lower lobes.

6a. 2nd and 3rd legs with endopodites greatly enlongated. *Tessarabracion* Hansen

6b. 2nd leg with endopodite greatly elongated.

7a. 2nd leg with endopodite rather strong, the last two segments armed with spiniform bristles on both margins. *Thysanoessa* Brandt (in part): *(T. gregaria, T. parva, T. inspinata, T. spinfera, T. longicaudata, T. macrura, T. vicina)*

7b. 2nd leg with endopodite very slender, naked except for a group of long apical bristles. *Nematoscelis* G. O. Sars

6c. 3rd leg with endopodite greatly elongated.

8a. 3rd leg with endopod slender, naked, except for a group of serrated apical bristles. *Nematobrachion* Calman

8b. 3rd leg with endopodite having penultimate segment broadened and forming, together with the last segment, a kind of prehensile hand with curved bristles. Ventral abdominal photophores lacking on all but first segment. *Stylocheiron* G. O. Sars

Genus *Thysanopoda* Milne-Edwards, 1830

Parathysanopoda Illig, 1909 (*fide* Hansen 1911: 14–15)

Generic diagnosis:

Eye spherical in adults.

1st segment of antennular peduncle with distal portion elevated abruptly as a heavy, posteriorly-rounded lobe, except in *tricuspidata*.

Thoracic legs generally similar in structure, none conspicuously elongated. Terminal segments of first two legs shortened, furnished with brush-like setae. 7th endopod distinctly shorter than preceding ones. 8th endopod extremely reduced.

Of the 13 species in the genus *Thysanopoda*, 10 are known to occur in the region of the Archipelago. Bathypelagic *T. spinicaudata* is known from the Indian and Pacific Oceans but not from southeast Asian waters. *T. microphthalma*, which may prove to be a form of *T. orientails*, is known from the Atlantic. *T. acutifrons* lives only at temperate latitudes in all three oceans.

Thysanopoda is based primarily on the presence of 7 thoracic legs and the rudiment of an 8th. The genus appears to be a natural group, with the possible exception of *T. tricuspidata*. This species not only lacks the structure of the antennular peduncle characteristic of other thysanopods, but its larval development has several unique aspects (Knight, 1973).

Key to the Species of *Thysanopoda*

1a. Lappet on 1st antennular segment produced dorso-anteriorly as an acute tooth, not elevated as a heavy posteriorly-rounded lobe.
Carapace with two lateral denticles on each side, and with long spiniform process projecting anteriorly from gastric dome ... *tricuspidata*

1b. Lappet an abruptly-elevated, heavy, posteriorly-rounded lobe. Carapace without lateral denticles or with only one on each side, and without spiniform process extending forward from gastric dome.

2a. Carapace with distinct cervical groove. Abdomen with 6th segment no longer than 5th and with short median and dorso-lateral keels on 4th and 5th segments. Adults large, >60 mm in length.

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3a. Frontal plate with dorsal spine.

    4a. 6th abdominal segment with heavy postero-lateral spine on each side ... *spinicaudata*

    4b. 6th abdominal segment without postero-lateral spines ... *cornuta*

3b. Frontal plate downward-curving, without dorsal spine... *egregia*

2b. Carapace without cervical groove. Abdomen with 6th segment longer than 5th and without keels on 4th and 5th segments. Adults typically 15–30 mm in length, but 35–65 mm in *cristata*.

    5a. Abdomen with median posterior spine on one or more segments.

        6a. Abdomen with spines on 4th and 5th segments. 2nd antennular segment without dorsal tooth ... *cristata*

        6b. Abdomen with spine on 3rd, sometimes also on 4th and 5th segments. 2nd antennular segment with dorsal anterior tooth ... *monacantha*

    5b. Abdominal segments without dorsal spines.

        7a. Carapace without lateral denticles.

            8a. Lappet pectinate anteriorly ... *pectinata*

            8b. Lappet angular anteriorly (in lateral view), not pectinate.

                9a. Petasma with terminal process extending barely short of tip of proximal ... *orientalis*

                9b. Petasma with terminal process extending beyond proximal ... *microphthalma*

                9c. Petasma with terminal process about 1/2 as long, and extending not as far, as serrate end of proximal ... *acutifrons*

        7b. Carapace with small lateral denticle on each side.

            10a. Lappet on 1st antennular segment produced beyond mid-point of 2nd segment and flaring laterally and outward, covering upper, outer part of 2nd segment.

                11a. Frontal plate in lateral view tapers, somewhat, distally. Propodal and dactyl segments of endopodite of 3rd thoracic leg of male unmodified ... *astylata*

                11b. Frontal plate of nearly same thickness distally as proximally. Propodal segment of endopodite of 3rd thoracic leg of male greatly reduced and dactylus modified as a long naked spine ... *aequalis*

            10b. Lappet on 1st antennular segment not produced as far as mid-point of 2nd segment ... *obtusifrons*

Thysanopoda tricuspidata Milne-Edwards, 1837
Figs. 81, 119a

T. tricuspide Milne-Edwards, 1830: 454, pl. xix. *T. tricuspida* Milne-Edwards, 1837: 45, pl. xxvi, figs. 1-6. *T. tricuspidata* Milne-Edwards, 1837: 466; pl. xxvi, figs. 1-6; G.O. Sars. 1885: 98–102, 165–169, pls. xvii, xxxi, figs. 1-22; Hansen, 1910: 82–84, pl. xii, fig. 3, a-b; 1912: 208, pl. iv, fig. 2a; Boden et al., 1955: 301–303, fig. 8. *Cyrtopia rostrata* Dana, 1852:130.

Eye: Medium-large

Antennular peduncle: Anterior dorsal margin of basal segment not produced as a lobe, but extends forward as a spine; outer distal edge of basal segment with a smaller spine. 2nd segment long, terminating dorsally as an acute triangular process which overlies 3rd segment. 3rd segment without keel.

Rostrum: Long and acute, extending to anterior limit of eye.

Carapace: A long, straight (forward-directed) spine extends from gastric region, approximately to posterior limit of eye. Lateral margin of carapace bears two widely-separated denticles.

Abdomen: Pleuron of 1st segment is deeply cleft at lateral limit, appearing almost as two plates. 3rd-6th segments bear median posterior spines.

Petasma: Terminal process is barely curved, slender, tapering to a flattened, slightly expanded end. Proximal process is as long as terminal, conspicuously expanded distally with that portion serrate or crenulated along its inner margin. The lateral process is slender, distally curving. The median lobe bears a strongly-curved additional process, distal to lateral process.

Length: 15–25 mm.

Remarks: The dorsal-anterior carapace spine is unique to *T. tricuspidata*. Peduncular and abdominal spines are useful supplementary means of identification.

<div style="text-align:center">

Thysanopoda cornuta Illig, 1905

Figs. 82, 119b

</div>

T. cornuta Illig, 1905: 663–664, figs. 1-3; Hansen, 1915; Boden et al., 1955: 313–314, fig. 14. *T. insignis* Hansen, 1905a: 19–21, figs. 18-19.

Eye: Small.

Antennular peduncle: Lobe on 1st segment heavy, domed and somewhat reflexed posteriorly, extending forward beyond midpoint of 2nd segment and terminating anteriorly as a short, upward-directed tooth situated above inner dorsal part of 2nd segment. 2nd and 3rd segments without processes.

Rostrum: Frontal plate extends forward, almost to anterior limit of eyes, as a very thick, obtusely convex shield, terminating antero-dorsally in a short, strong spine.

Carapace: Cephalic region heavily keeled dorsally with short secondary crest at highest point. Distince cervical groove extends transversely across carapace behind head. There is a lateral furrow above margin of thoracic part of carapace.

Abdomen: 4th and 5th segments each bear three small dorsal and sub-dorsal keels. 6th segment almost as long as 5th.
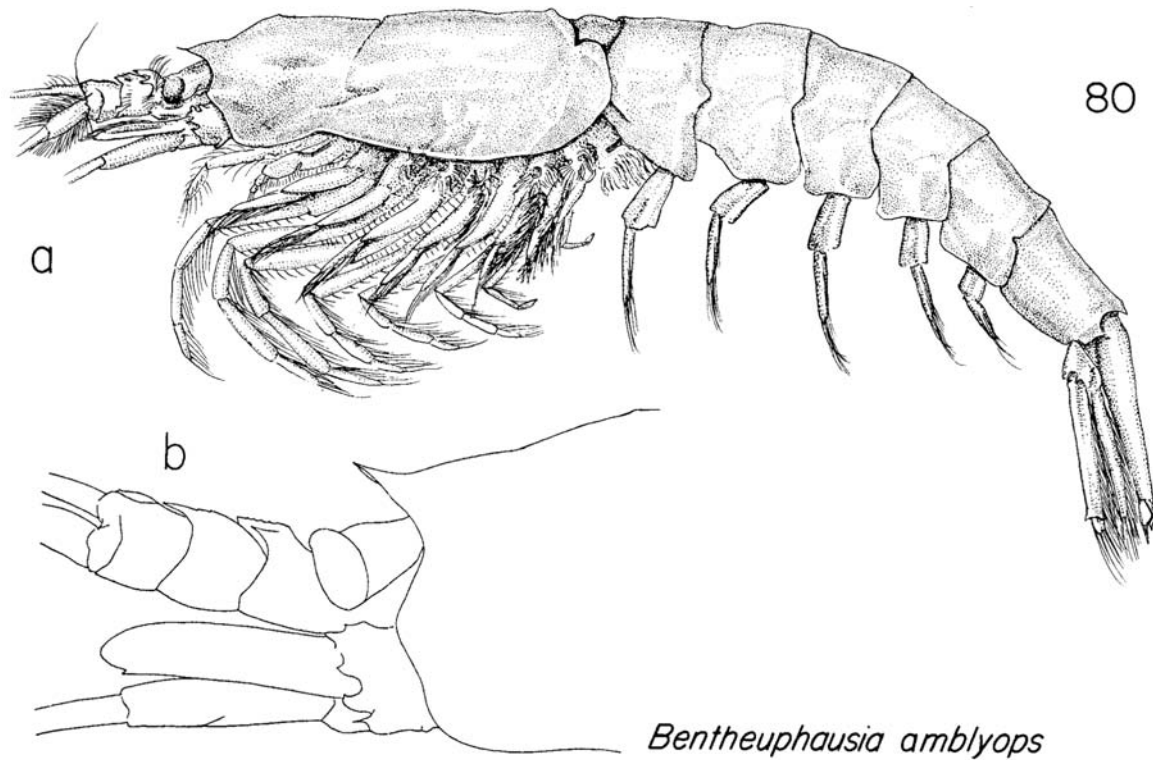
Figure 80. a) *Bentheuphausia amblyops*; b) head region and peduncles of antennae, male; c) peduncles of antennae, female.
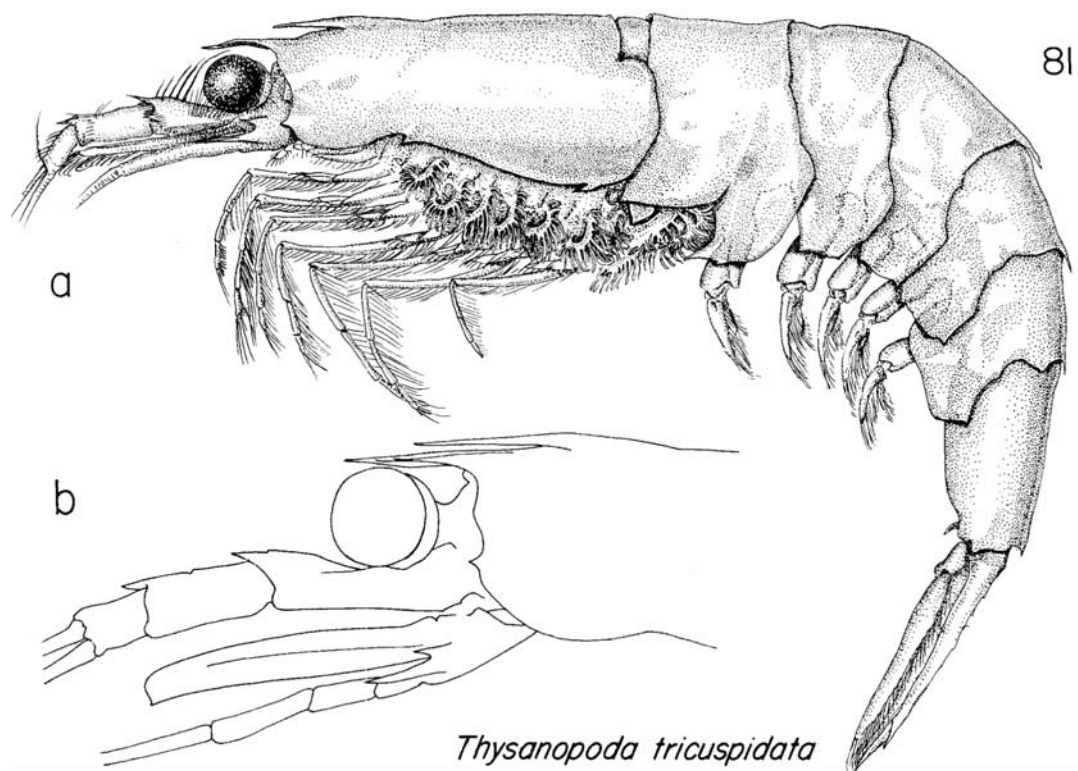

Figure 81. a) *Thysanopoda tricuspidata*; b) head region, peduncles of antennae.

Petasma: In adult males (50 and 95 mm in length) from the eastern Pacific, terminal and proximal processes are somewhat curving, tapering acutely, and nearly equal in length. Lateral process is shorter, curved but scarcely hooked, and flanked by one or two short additional processes.

Remarks: As in the case of *T. egregia*, only young specimens of this large bathypelagic species were caught in waters of the southeast Asian region. These are large (6–10 mm as furcilia) with large eyes, and with smooth carapace (Fig. 126) differing from *T. egregia*, the furcilia of which have "ripple markings" on the carapace. The related species *T. spinicaudata* has a longer, more nearly vertical rostral spine and heavy posterior-lateral spines on the 6th abdominal segment (Fig. 83). The petasma (of a 95 mm specimen) is similar to that of *T. cornuta* but is with shorter and stouter terminal and proximal processes (Fig. 119c).

<center>*Thysanopoda egregia* Hansen, 1905</center>
<center>Figs. 84, 119d</center>

T. egregia Hansen 1905a: 22–23, figs. 20-21; Brinton, 1953: 408–411, figs. 2, 7, 12, 13; Boden et al., 1955: 314–316, fig. 15. *T. megalops* Illig, 1908a: 54–55, figs. 1-2; 1911: 45–46 (*fide* Sheard, 1942: 61).

Eye: Small.

Antennular peduncle: Dorsal-anterior lobe on basal segment consists of a reflexed ridge encasing elevated proximal part of 2nd segment. In lateral view, anterior (inner) limit of lobe merges with 2nd segment and does not drop down to it angularly. There is an anteriorly-directed, scarcely elevated tooth at that anterior limit of the lobe 2nd and 3rd segments without processes. The peduncle of the 2nd antenna is very broad and stout.

Rostrum: Frontal plate with thick keel which, at its anterior limit, bends downward, terminating as low, transverse ridge, situated above and between eyes.

Carapace: The head and gastric regions heavily keeled, with short additional crest at highest point. A distinct dorso-lateral transverse cervical groove separates head from thorax. There is a lateral furrow above margin of thoracic portion of carapace.

Abdomen: 4th and 5th segments each bear three small dorsal and subdorsal keels. 6th segment equal in length to 5th or a little shorter.

Petasma: This structure, from a 53 mm male, appears to be mature. The terminal and proximal processes are curved, tapering to acute tips, and slightly bent at their midpoints, tapering distally, sub-acute at the finger-like tip. Proximal process is the longer. Median lobe bears three curved processes, the two innermost being stout, acute and equal in length and the third, which projects from the tip of the lobe, is shorter.
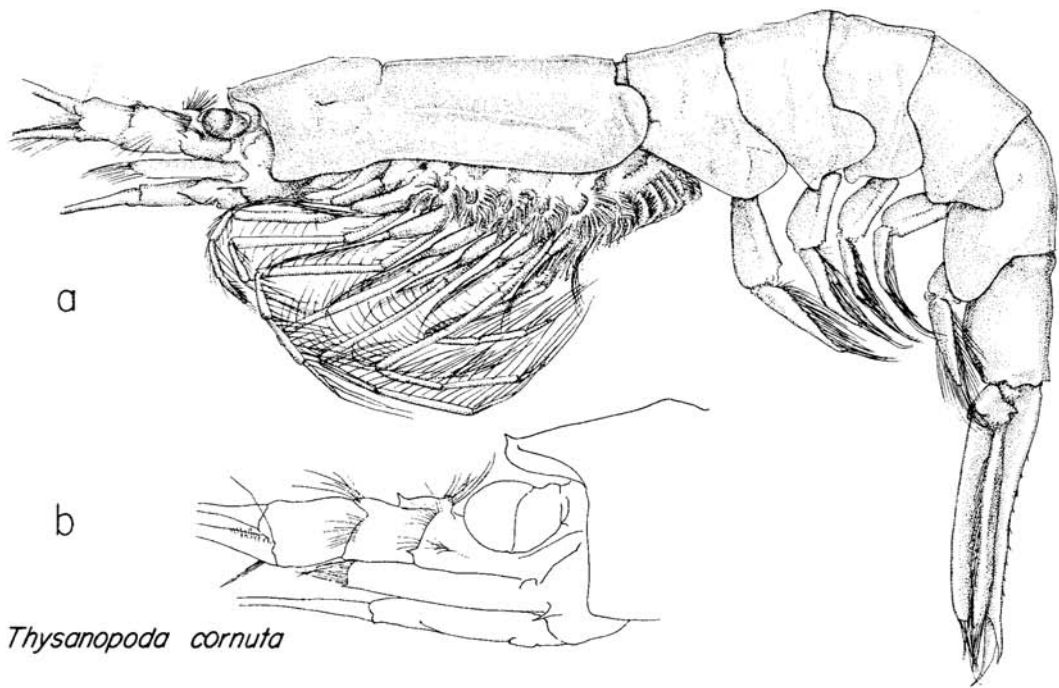
Figure 82. a) *Thysanopoda cornuta* adult; b) head region and peduncles of antennae of juvenile 26 mm in length, from 19°N, 123°E.
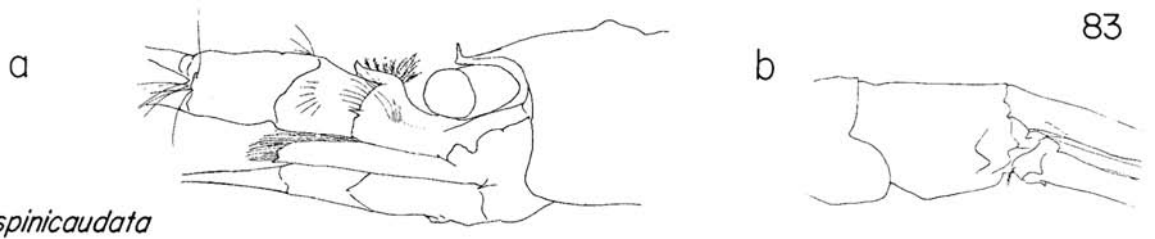
Figure 83. a) *Thysanopoda spinicaudata*, head region and peduncles of antennae of juvenile 25 mm in length, from 26°S, 156°W; 6th abdominal segment of same specimen, showing developing postero-lateral spine.
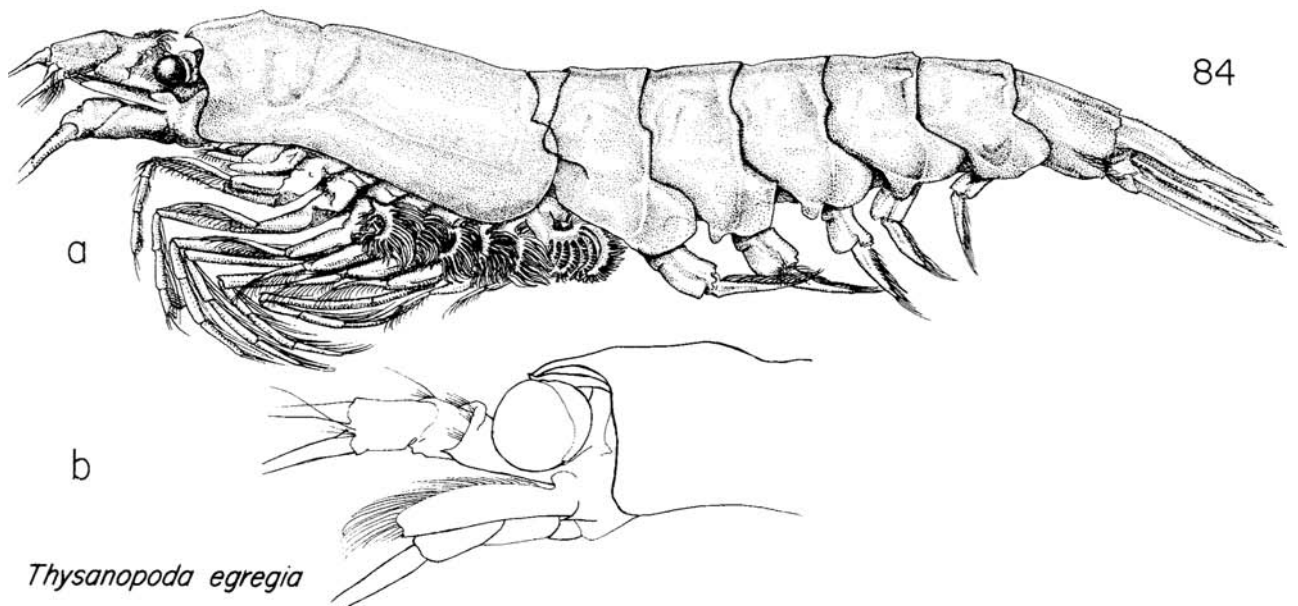
Figure 84. a) *Thysanopoda egregia* adult; b) head region and peduncles of antennae of juvenile 15.4 mm in length.

Remarks: only young specimens of this species were found in southeast Asian waters, the adults apparently living at greater depths than were sampled. Furcilia stages, 4.6–13 mm in length bear conspicuous "ripple markings" on the carapace and the eye is large. These correspond to Tattersall's (1939) "Species A", as has been pointed out (Brinton, 1962a).

Thysanopoda cristata G.O. Sars, 1883

Figs. 85, 119e

T. cristata G. O. Sars, 1883: 22; 1885: 104–106, pl. xviii, figs. 15-20; Hansen, 1912: 209–212, pl. III, fig. 4, a-c, pl. IV, fig. 1, a-h; Boden et al., 1955: 300–201, fig. 7. *T. biproducta* Ortmann, 1893: 8, taf. 1, fig. 1.

Eye: Large.

Antennular peduncle: Dorsal anterior margin of basal segment raised as hood over base of 2nd segment. This hood is relatively high and short (antero-posteriorly) compared with the same structure in other *Thysanopoda* species. 2nd segment not produced anteriorly as process, but as low triangular cover adhering closely to dorsal surface of 2nd segment. 3rd segment without keel but dorsal-distal part is somewhat elevated.

Rostrum: Slender, acute, reaching to anterior limit of eye. Frontal plate with conspicuous keel which extends forward, but not to tip of rostrum, and ends abruptly as an elevated tooth well above the rostrum.

Carapace: The keel on frontal plate becomes higher in gastric region, extending posteriorly to midpoint of thoracic region. There is a sub-marginal lateral furrow on each side of the carapace and postero-lateral denticle.

Abdomen: 4th and 5th segments bear median posterior spines. 6th segment is short, scarcely longer than 5th.

Petasma: Terminal and proximal processes slender, curving and tapering to sub-acute flattened ends. Lateral process long, tapering to hooked end, A plate-like outgrowth of median lobe lies beside distal hook of lateral process.

Length: 35–65 mm.

Remarks: The high vaulted lobe of the 1st segment of antennular peduncle, the anteriorly notched keel on frontal plate, and the spines on 4th and 5th abdominal segments are distinctive for *cristata*. This species grows larger than was previously known. We have a 65 mm female from the mid-North Pacific.
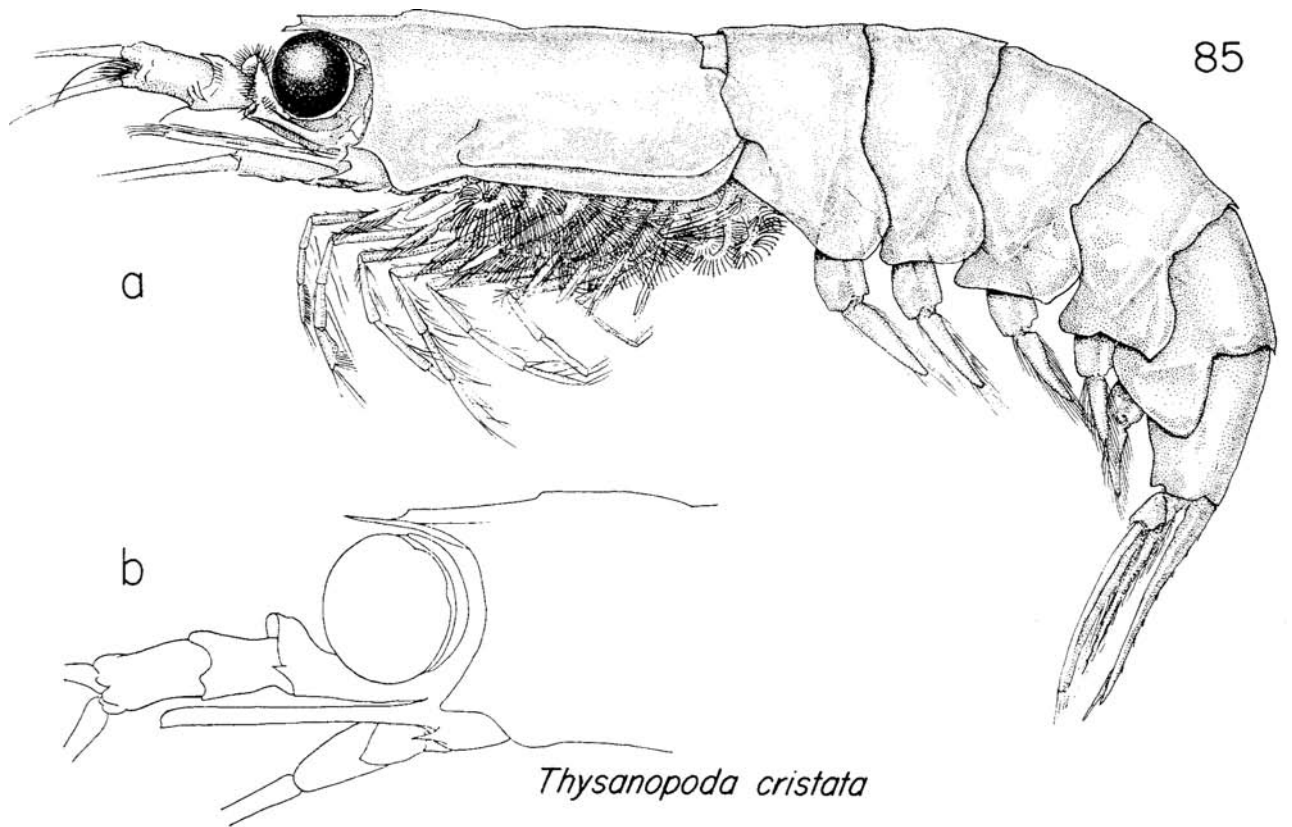
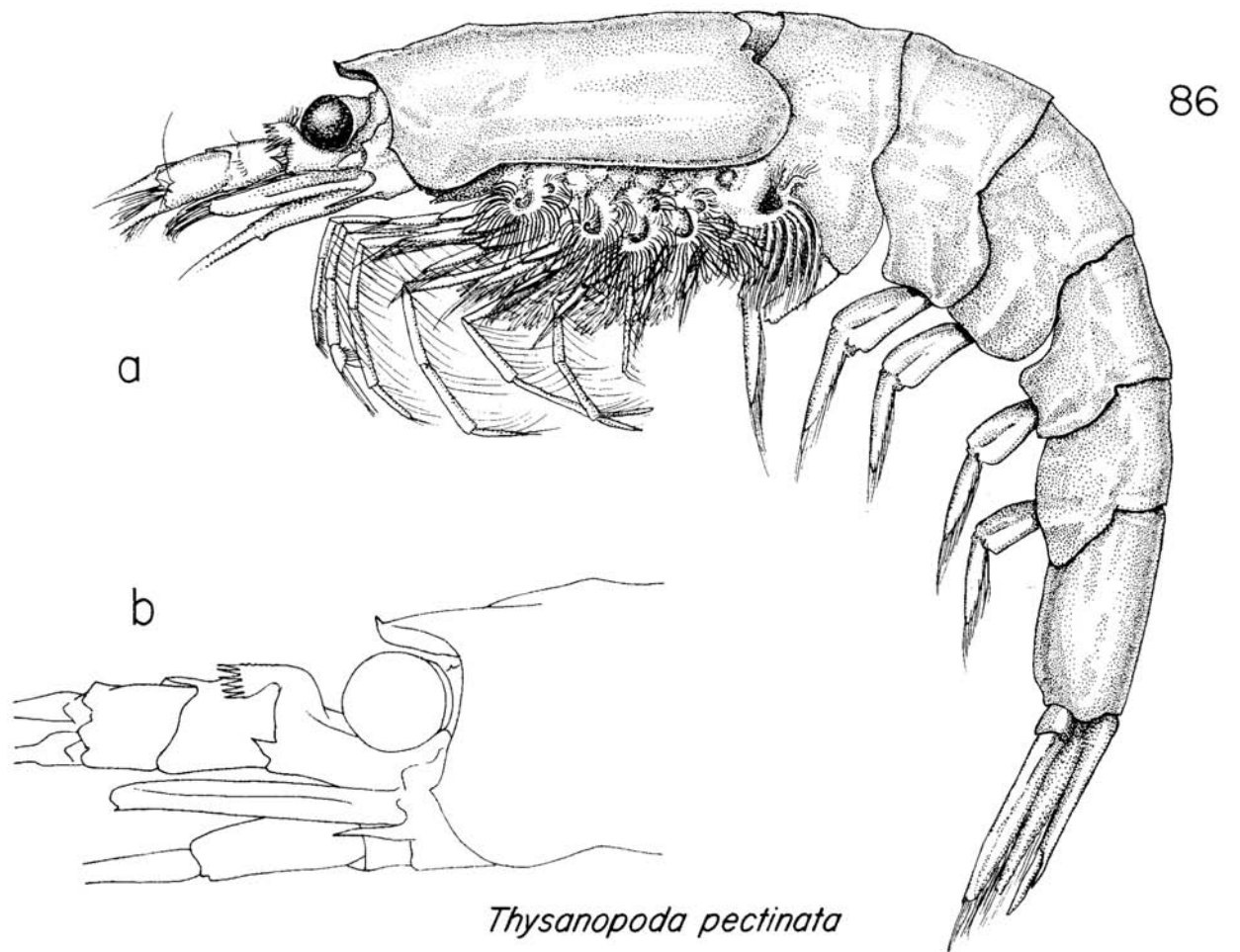Figure 85. a) *Thysanopoda cristata;* b) peduncles of antennae and head region.

Figure 86. a) *Thysanopoda pectinata;* b) peduncles of antennae and head region.

<div align="center">Thysanopoda pectinata Ortmann, 1893</div>
<div align="center">Figs. 86, 119f</div>

T. pectinata Ortmann, 1893; 10, taf. 1, fig. 4; Hansen, 1905b: 25–26; 1912: 218–222, pl. 5, fig. 1, a-m; Illig, 1930: 510–512, figs. 192–193; Boden et al., 1955: 307–309, fig. 11. *Parathysanopoda foliifera* Illig, 1909: 225: Hansen, 1911: 14–15.

Eye: Medium sized.

Antennular Peduncle: Lobe on basal segment extends forward over base of 2nd segment as pectinate flap, with 10–13 comb-like spines. Distal dorsal surface of 2nd segment expanded anteriorly as flat covering for portion of 3rd segment. 3rd segment with low keel.

Rostrum: A small upward-directed tooth is situated at the anterior limit of broadly triangular, thickened frontal plate.

Carapace: Without lateral denticles or processes other than the rostral tooth.

Abdomen: Without dorsal spines.

Petasma: Terminal process broadly based and distally expanded into rounded end concave on inner surface. Above its base, proximal process bends inward, then sharply outward, before terminating in flattened plate with distal tooth or teeth. Lateral process distally hooked. Additional process broad, curved, and distally acute.

Length: 29–44 mm.

Remarks: The pectinate lobe on the basal segment of the antennular peduncle, together with the conical, sharply upturned rostral process, characterizes this species.

<div align="center">Thysanopoda monacantha Ortmann, 1893</div>
<div align="center">Figs. 87, 119g</div>

T. monacantha Ortmann, 1893: 9, taf. 1, fig. 2; Hansen, 1912–212–213, pl. iv, fig. 3, a-c; Boden et al., 1955: 298–300, fig. 6. *T. agassizi* Ortmann, 1894: 99, pl. figs. 1-2; Hansen, 1910: 87–89, pl. xiii, fig. 3, a-g. *T. lateralis*, Hansen, 1905a: 18–19, figs. 14-16. *T. ctenophora* Illig, 1908b: 112–113, fig. 1. *T. mansui* Marukawa, 1928 (*fide* Ponomareva, 1963: 17).

Eye: Medium sized.

Antennular peduncle: Setose lobe on upper distal margin of 1st segment extends anteriorly as spiniform process directed somewhat outward and downward, reaching to midpoint of 2nd segment. 2nd segment also extends anteriorly as slender, acute, dorsal process, overlying the basal part of 3rd segment. A high keel is situated on inner dorsal surface of 3rd segment.

Rostrum: An acute forward directed, triangular plate, reaching almost to anterior limit of eye.
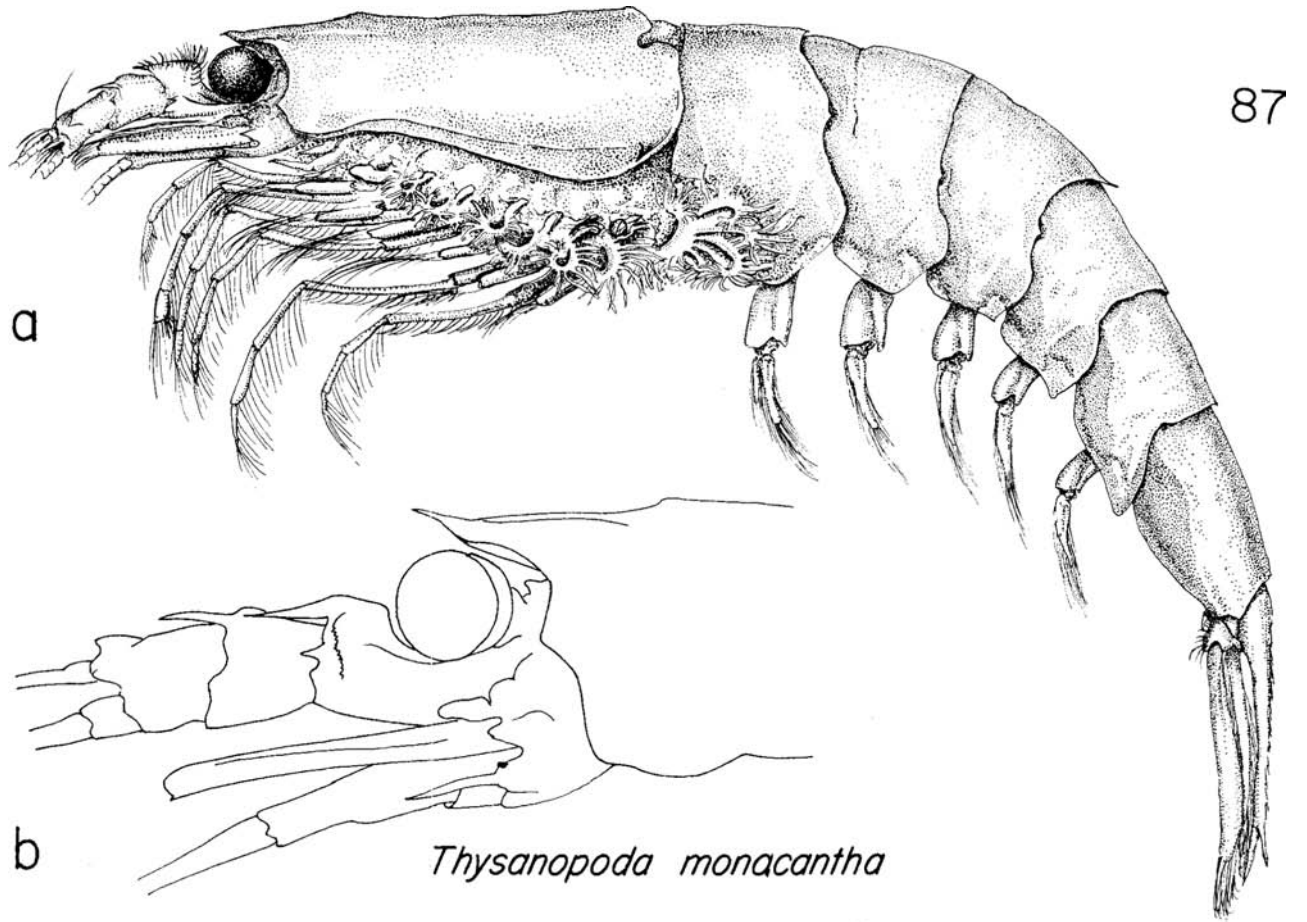
87

a

b

Thysanopoda monacantha

Figure 87. a) *Thysanopoda monacantha;* b) peduncles of antennae and head region.
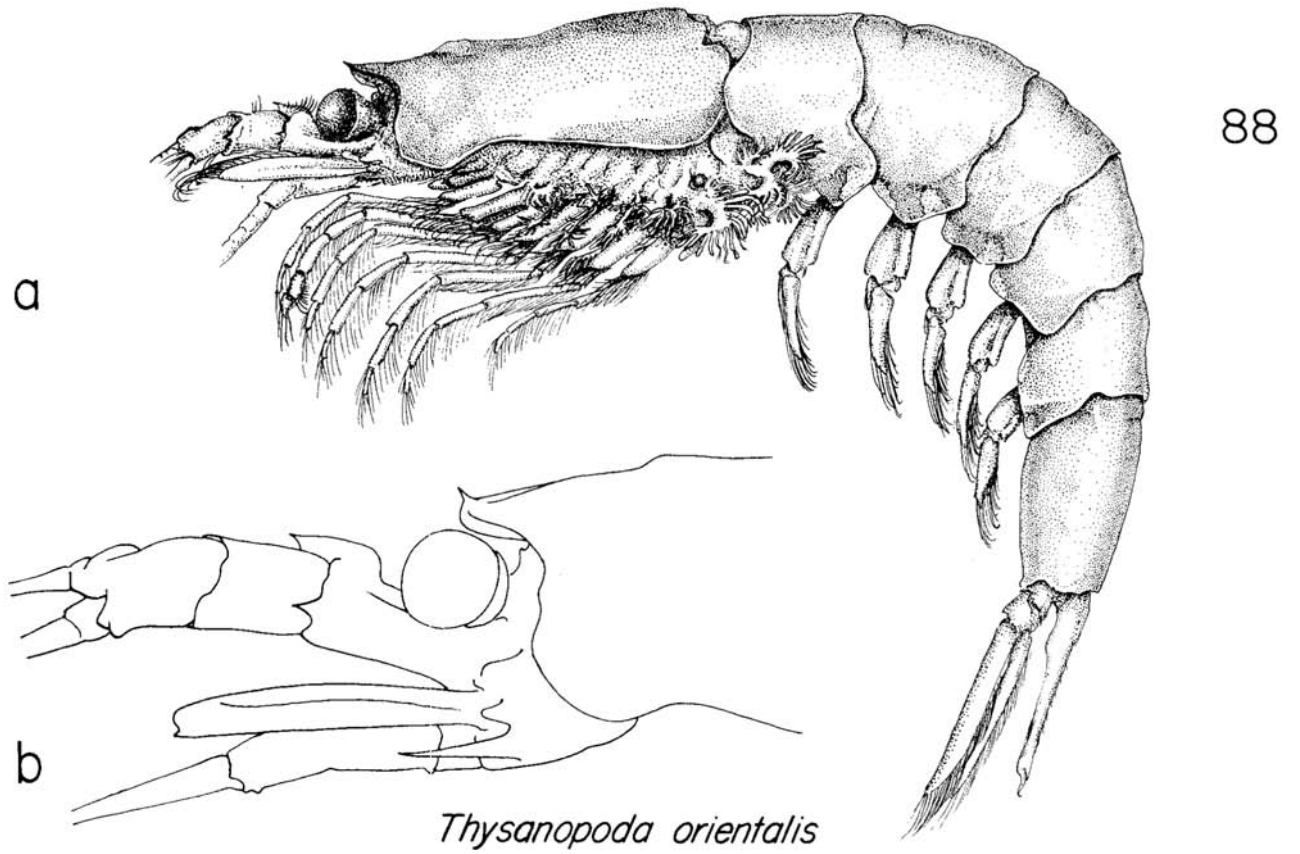

88

a

b

Thysanopoda orientalis

Figure 88. a) *Thysanopoda orientalis;* b) peduncles of antennae and head region.

Carapace: A longitudinal furrow extends the length of carapace just above and paralleling lateral margin. Margin of carapace with postero-lateral denticle.

Abdomen: 3rd segment bears mid-dorsal posterior tooth. 4th and 5th segments each sometimes with small tooth or slightly acuminate.

Petasma: Terminal process curves somewhat outward above a broad base, then tapers symmetrically to an acute tip. Proximal process of similar length and thickness, but angles sharply inward, toward terminal process, above stout basal portion. Lateral process nearly straight, reaching almost to limit of median lobe. Additional process half as long, slightly curved.

Length: 25–32 mm.

Remarks: The spiniform extensions of the first two segments of the antennular peduncle, and the tapering forward-directed rostral process are characteristic.

Thysanopoda orientalis Hansen, 1910

Figs. 88, 119h

T. orientalis Hansen, 1910: 85–87, pl. xiii, fig. 2, a-i; 1912, 222–223, pl. v, fig. 2, z-i; Boden et al., 1955: 309–311, fig. 12.

Eye: Small-medium sized.

Antennular peduncle: Lobe at distal end of basal segment abruptly elevated, continuing high over short portion of 2nd segment and ending as acute angle, the lower edge of which drops off sharply to upper surface of 2nd segment. Anteriorly, dorsal part of 2nd segment extends over base of 3rd as a low cover.

Rostrum: A short forward- and upward-pointing tooth situated at apex of the thick, broadly triangular frontal plate. In immature specimens (about 15–23 mm) the rostral process, seen laterally, is long, spiniform, and more anteriorly directed than in the adult.

Carapace: Lateral margin without denticles.

Abdomen: Without teeth, but median posterior margins of 4th and 5th segments are barely acuminate.

Petasma: Terminal process strong, straight, ending as bluntly rounded spoon-like lobe of same width as stem of process. Proximal process strongly curved, almost in semicircle, extending inward, then upward and over end of terminal process. On its distal underside it is toothed. Lateral process long, tapered and distally hooked. There is one lobe-like additional process. One or two short spiniform additional processes are sometimes present.

Length: 23–38 mm.

Remarks: *T. orientalis* is larger than *obtusifrons* though with respect to the frontal plate and rostral process they are similar. The antennular lobe is more elevated and angular distally than in *obtusifrons* or *aequalis-subaequalis*. *T. acutifrons* (Fig. 119j) is a high-latitude sibling of *orientalis*. *T. microphthalma* (Fig. 119i), not known from the Pacific, is even more similar to *orientalis* (see above key to *Thysanopoda*).

Thysanopoda aequalis Hansen, 1905

Figs. 89 a, b, d, e, 119 k, l

T. aequalis Hansen, 1905b: 18–20; 1910: 84–85, pl. xii, fig. 4 a-b (?c), pl. xiii, fig. 1a; Zimmer, 1914: 417–418, figs. 53, 54; Tattersall, 1924: 15–16, pl. ii, figs. 5, 6; *T. subaequalis* Boden, 1954: 190–192, fig. 5; Boden, Johnson and Brinton, 1955: 297; Boden and Brinton, 1957: 337–341, figs. 1-2; Bacescu and Mayer, 1961: 180–190, fig. 4a; James: 1970: 226; Baker, 1970: 311–313; Weigmann, 1974a: 23–24.

Eye: Medium sized.

Antennular peduncle: Lobe at distal end of basal segment heavy and posteriorly rounded, directed upward, then somewhat backward, before it flaps forward over 2nd segment about as far as midpoint of that segment, to which it adheres closely. Outer part of flap extends downward and even farther forward, ending as an acute triangle on side of 2nd segment, beyond its midpoint. 2nd and 3rd segments without processes, but 2nd has "upper inner end produced into a rather short lobe covering a rather small part of third joint, as in (*T. obtusifrons*) and some other species" (Hansen 1905b).

Rostrum, frontal plate: Tip of frontal plate sometimes bears a minute vertical tooth which, in dorsal view, does not project anteriorly from the smoothly rounded anterior margin of the frontal plate (Fig. 89e). This tooth is frequently lacking. As stated by Hansen (1905b), "Seen from the side, the front tip of the carapace scarcely shows any vestige of the minute vertical tooth observed in (*T. obtusifrons*)." Behind tip of frontal plate there is a shallow longitudinal trough bordered by low, broad, poorly defined ridges. Posterior part of trough contains, medially, a low keel which extends posteriorly to a point about one-third of dorsal carapace length from front. Viewed from side, frontal plate appears as a thickened lobe, dorsal and ventral surfaces of which are almost parallel, scarcely converging anteriorly until the bluntly rounded front end. Frontal plate usually narrow (Fig. 89 c, f), its breadth1 as a fraction of the total length of the animal, is in the range of .032–.049 for the Pacific and Indian Ocean Specimens measured. It is .047–.063 for the specimens from the type localities in the northeastern Atlantic.

Carapace: Head region broad, dorsally flattened, only slightly elevated as keel in gastric region, described above. There is a postero-lateral denticle.

3rd thoracic leg: In the adult male, about 12 mm in length, propodus stouter than in other thoracic legs, dactylus reduced but bears a long, strong spine. In female, distal segments as in 4th-7th legs.

Abdomen: Without spines or keels.

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[1]Breadth of frontal plate is arbitrarily taken as breadth measured midway between anterior tip and a transverse dorsal line directly above the posterior limits of the orbits (Fig. 89e).

Petasma: Spine-shaped process small, slender, almost straight, occasionally lacking. Terminal process tapering, directed somewhat outward, then curving inward before again reflexing distally; distal portion flattened but tip appears acute. Proximal process longer than terminal, curvature as in terminal but inward bend above basal portion is somewhat angular. Configuration of proximal process is S-shaped; near tip, process narrows and anterior-outer surface bears 1–3 minute papillae, barely visible at 600X magnification. Terminal and proximal processes longer and more slender in large specimens (cf. fig. 119 1,m). Lateral process strong, almost as long as terminal, tapering, and distally curved; outline of inner margin concave, providing basal portion with heel-like aspect. Additional process a strongly curved hook with distal portion angling sharply inward.

Length: 12–19 mm.

Remarks: This is the species described as *T. subaequalis* by Boden (1954). Hansen's (1905b) omission of mention of the long styliform process on the dactylus of the 3rd thoracic leg led to the assumption by Boden (1954), Boden and Brinton (1957), Brinton (1962) and others that, of the two species here recognized as constituting a sibling pair, Hansen described the one which possesses an unmodified 3rd leg.

Reexamination of the type material from Monaco utilized for the original description (Hansen, 1905b) (no type specimen was designated by Hansen) revealed that the description was based upon 26 adult specimens, collected at 10 localities between the Azores and Canary Islands in the northeastern Atlantic. There were 6 males: all (except one which had the thoracic legs broken off) possessed the long stylate seta on the reduced dactylus of the 3rd leg. The reexamination of this question was prompted by the realization that the literature and our available material contain no instances of the un-spined species occurring in the Atlantic. It appears not to be present there (Fig. 49a). *T. subaequalis* Boden must therefore be considered a junior synonym for *T. aequalis* Hansen, and the species with the unspined 3rd thoracic leg be redesignated. The name *Thysanopoda astylata* is proposed and this species is described below. A comparison of it with *T. aequalis* (thoracic leg, frontal plate, petasma) follows the description.

In the above synonymy those references are listed which distinguish between the spined (3rd leg) and unspined forms or contain an illustration otherwise referable to the spined form (i.e. Hansen, 1910, in which the dorsal view of the narrow frontal plate is like the typical *T. aequalis* illustrated here, figure 89d). References to all specimens of *T. aequalis-subaequalis* from the Atlantic Ocean are here considered referable to *T. aequalis*.

A number of other pre-1954 and a few post-1954 observations citing *T. aequalis* might indeed be correctly referring to that species here constituted, judging from what is now known about its distribution (Fig. 49a). These and certain of the Atlantic references are as follows:

T. aequalis, Tattersall, 1927; Ruud, 1936; Leavitt, 1938; Lebour, 1949; Moore, 1950, 1952; Nemoto, 1965; Casanova-Soulier, 1968. *T. obtusifrons*, LoBianco, 1901; Thiele, 1905. *T. microphthalma*, LoBianco, 1903. *T. aequalis* variety *latifrons,* Colosi, 1916. *T. subaequalis*, Brinton and Gopalakrishnan, 1973. *T. subaequalis-T. aequalis*, Casanova, 1974.

Some other references are to specimens which are not presently determinable as far as separating *T. aequalis* from *T. astylata* is concerned, either on morphological or distributional grounds. These, which may include specimens of both, are as follows: *T. obtusifrons*, Ortmann, 1905. *T. aequalis*. Hansen, 1912, 1915; Tattersall, 1912, 1939; Iilig, 1930; Ponomareva, 1963; Weigmann, 1970; Roger, 1973a.
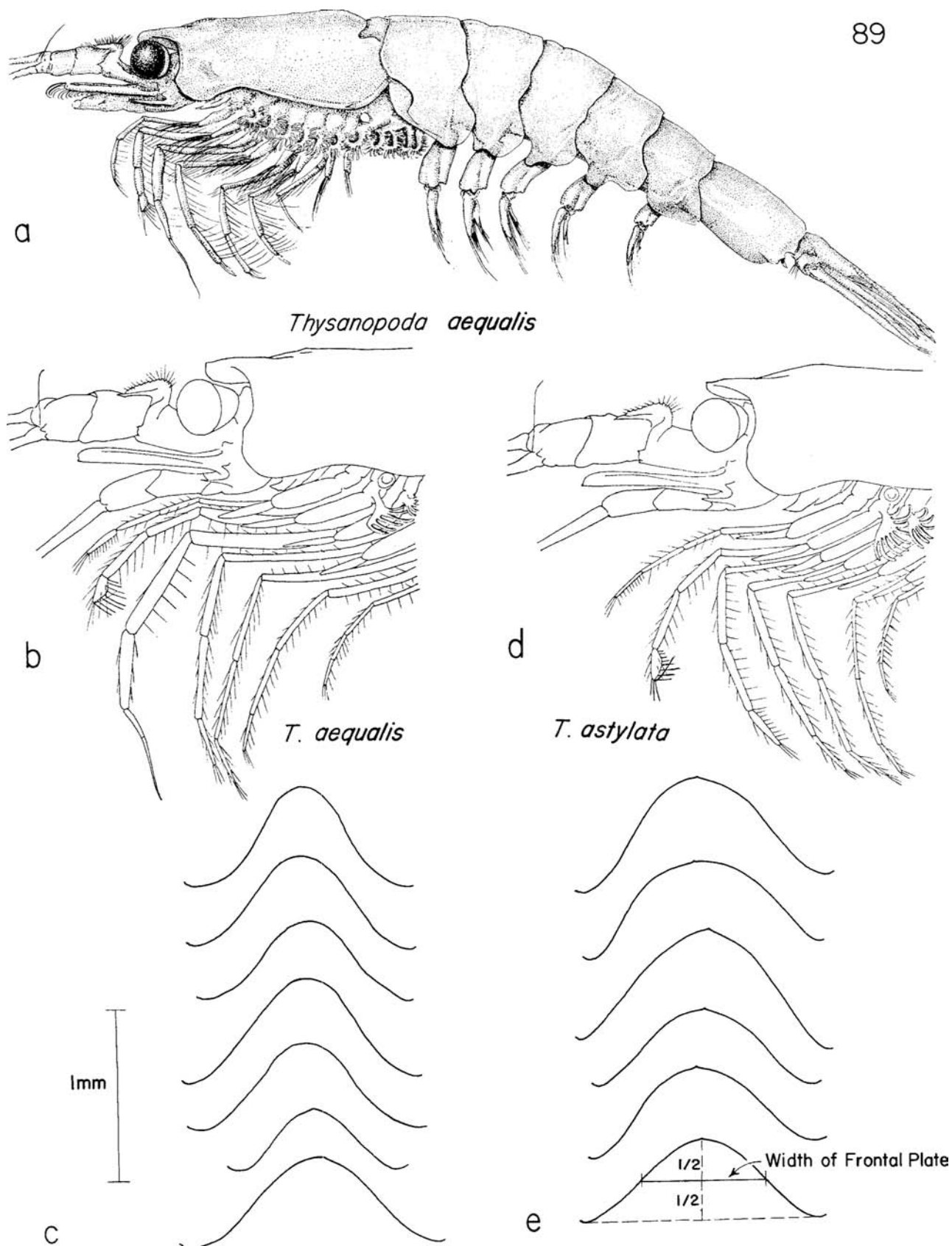
Figure 89. a) *Thysanopoda aequalis;* b) *T. aequalis*, peduncles of antenna, head region and thoracic legs of male, showing characteristic shape of frontal plate and 3rd thoracic leg; c) *T. aequalis*, dorsal view of frontal plate of 7 specimens from different localities; d) *T. astylata*, showing characteristics of frontal plate and 3rd thoracic leg; e) *T. astylata*, dorsal view of frontal plate of 6 specimens, from different regions, showing place at which width was measured.

Thysanopoda astylata, new species
Figs. 80 d-f, 119 n,o

T. aequalis Boden, 1954; 190, fig. 4 c-f; Boden, Johnson and Brinton, 1955: 303–305, fig. 9; Boden and Brinton, 1957: 337–340, figs. 1a, 2c; Brinton and Gopalakrishnan, 1973: 368–369, fig. 9 a,b.

Type: Adult male, 16 mm in length, Equapac expedition, R/V *Horizon*, Sta. 8, 2°N, 164°E.

Paratype: Adult female, 16 mm in length, same locality.

Eye: Medium sized.

Antennular peduncle: As in *T. aequalis*. Lobe at distal end of basal segment heavy, posteriorly rounded and directed upward before it flaps forward over 2nd segment about as far as midpoint of that segment, to which it closely adheres. Outer part of flap extends downward and forward of inner part, ending at an acute angle on side of 2nd segment, beyond its midpoint. 2nd and 3rd segments without processes, but 2nd has upper inner and extending anteriorly as a short lobe.

Rostrum, frontal plate: Tip of frontal plate bears a minute upward-directed tooth which barely leans anteriorly beyond the otherwise rounded (in dorsal view) anterior margin of frontal plate. Behind tip of frontal plate there is a shallow longitudinal trough bordered by low but sharply defined ridges. Posterior part of trough contains, mesially, a low keel which extends posteriorly to a point about one-third of dorsal carapace length from rostral tip. Viewed from side, frontal plate appears as anteriorly-tapering lobe, the anterior-most upper surface of which bends slightly upward terminating in the small toothlike projection. Frontal plate broad, its breadth (at the point midway between the tip and the posterior margin of the orbit, fig. 89e), as a fraction of the total length of the animal, is in the range of .041–.060.

Carapace: Broad, dorsally flattened behind anterior excavation (trough), slightly elevated as keel in gastric region, described above. Postero-lateral denticle present.

3rd thoracic leg: Not modified in either sex, dactylus proportionate in length with dactylus of other legs.

Abdomen: Without spines or keels.

Petasma: Spine-shaped process small, slender, almost straight. Terminal process tapering, directed somewhat outward, slender in large specimens, more robust in smaller specimens, Tip subacute, flattened, extends beyond tip of proximal process. Proximal process curves outwardly beyond basal portion but in a gentle arc, not angularly. Slender distal part, before tip, bears 1–3 minute papillae. Lateral process curves forward and outward distally, inner margin of basal half straight or barely concave, broadened base not abruptly demarked from trunk of process. Additional process curves outward through 90° arc, not angularly hooked, may extend well beyond end of median lobe in large (>15 mm) specimens.

Length: 12–18 mm.

Remarks: *T. astylata* is the species long assumed, particularly by workers in the eastern Pacific, to be that described by Hansen (1905) as *T. aequalis*. It is not characterized by a distinct modification of the 3rd thoracic leg but resembles other *Thysanopoda* species with respect of general uniformity of thoracic legs. It was accidental that Hansen failed to note the modified 3rd leg in his male specimens collected by the Prince of Monaco. Boden justifiably believed that his

specimens from South Africa-Mozambique, described as *T. subaequalis* (1954), differed from them.

Lomakina (1968) argued that the presence of transitional characters on occasional specimens (secondary setae and incompletely developed terminal spine on dactylus of male 3rd leg) showed that *T. aequalis-T. subaequalis* represented a peculiar case of male dimorphism and that characteristics of the male 3rd leg could not be regarded as criteria for isolating them into separate species. However, Lomakina noted that the transitional characters were found in specimens of 13 mm length. This is within the 10.5-13.5 mm size range in which males reach maturity, the period of development during which the 3rd leg of *T. astylata* becomes modified from the juvenile state in which it is like the other thoracic legs.

There are two indications that *T. aequalis* and *T. astylata* are separate species: the different areas of distribution, and the fact that the male 3rd leg in *T. aequalis* becomes modified only at sexual maturity - evidently an adaptive mechanism for reproductive isolation from *T. astylata*. It is particularly interesting to observe this form of morphological divergence occurring in sibling species; characteristics of the 2nd and 3rd thoracic legs are generic criteria elsewhere in the Euphausiacea.

No additional absolute character for separation of the two species is evident. Apparent small differences in the petasmas may be a consequence of the positioning of the processes - artifacts of the process of preparation. The terminal process appears less flexed in *T. astylata* than in *T. aequalis* and consistently extends beyond the end of the proximal process, whereas in *T. aequalis* this has been noted only in specimens < 15 mm in length. In *T. aequalis* the proximal process shows an angular inward bend above the base, whereas this flexure is more evenly curved in *T. astylata*. Similarly, the additional process appears more angularly hooked in *T. aequalis*. The lateral process bears a more clearly demarked heel-like basal portion in *T. aequalis*.

The frontal plate frequently, but not always, provides useful characters for separating the two species in the two oceans where they co-occur: in specimens of *T. astylata* from the Pacific and Indian Oceans, this structure becomes increasingly thin distally, terminating in a small antero-dorsally directed tooth, and the frontal plate is relatively broad (Fig. 89 d-f) with clearly defined keels bordering the dorsal mesial trough. In *T. aequalis* the frontal plate appears more lobe-like and thicker in lateral view and generally narrower in dorsal view. Thus, thickening of the plate is associated with its narrowing, the volume of it perhaps being constant for the two forms together. Again, the observed difference may be more related to tissue state in relation to mode of preservation than to natural shape. However, this difference is usually discernable, the breadth of the frontal plate (measured as in Fig. 89e) being significantly wider ($p < .01$, F test on mean squares) in *T. astylata* as compared with *T. aequalis* (not including Atlantic specimens). The slopes of the regressions for width-of-frontal-plate/body-length do not differ significantly ($p \sim .50$), indicating that broadening of the plate and lengthening of the body take place at the same rate in both species.

The relatively few Atlantic specimens of *T. aequalis* that have been measured are more like *T. astylata* with respect to breadth-of-frontal plate/body length (values ranging from .047-.063 in Atlantic *T. aequalis*, and .041-.060 in Pacific-Indian Ocean *T. astylata*).

Thysanopoda obtusifrons G.O. Sars, 1883

Figs. 90, 119m

T. obtusifrons G.O. Sars, 1883: 21-22; 1885: 102-104, pl. xii, figs. 1-14; Hansen, 1910: 81; 1912: 215-217, pl. iv, fig. 5, a-f; Boden et al., 1955: 303-307, fig. 10. *T. vulgaris* Hansen, 1905a: 15. *T. distinguenda* Hansen, 1905a: 17-18, fig. 13 (*fide* Illig, 1908b: 114-115).

Eye: Medium sized.

Antennular peduncle: Lobe at distal end of basal segment an abruptly elevated hood or thickened flap that overlies less than half of 2nd segment, appearing to adhere to it. This flap is dorsally almost flat in lateral view, and narrow, not flaring outward over side of 2nd segment. In fresh specimens, setae covering lobe are reddish. 2nd and 3rd segments without projection.

Rostrum: Frontal plate thick, rounded anteriorly, with small distal, upward-directed, conical tooth.

Carapace: Gastric region only slightly elevated. There is a postero-lateral denticle.

Abdomen: Without spines or keels.

Petasma: Terminal process nearly straight; distal one-third flattened with outer margin serrate and inner margin convex. Proximal process with acute heel just beyond base, strongly curving and flattened distally. Lateral process and additional process of nearly equal length, slender and curving distally.

Length: 18-22 mm.

Remarks: The frontal plate and short rostral spine are sometimes indistinguishable from those of *aequalis-astylata* or immature *orientalis*. The narrow peduncular lobe, not flaring outward, separates *obtusifrons* from the former pair, while the low or negligible elevation (with respect to upper surface of 2nd peduncular segment) of the most distal part of the lobe separates it from *orientalis*.

<p align="center">Genus Pseudeuphausia Hansen, 1910</p>

Generic diagnosis:

  Eye of medium size, width being 1/18-1/24 of body length.

  First segment of antennular peduncle with low, pectinate, anteriorly-directed lappet.

  Rostrum lacking but frontal plate projects anteriorly, beyond midpoint of eye, as a rectangle, anterior margin somewhat concave. Frontal plate and its projection dorsally concave, like a trough.

  Three distal segments of 6th thoracic leg of male are, together, half as long as those of 5th leg. In female, 3rd and 4th segments of 6th thoracic leg curve forward and the three terminal segments are, together, half as long as terminal segment of 5th leg.

  Petasma inner lobe bears three or four small spine-shaped processes, and no other processes. Median lobe bears long, leaf-shaped plate extending well beyond limit of lobe. Auxiliary lobe lacking. Setiferous lobe slender without setae.

  Body length is 8-15 mm.

  The genus was considered monospecific until Wang and Chen (1963) described *Pseudeuphausia sinica*, an inhabitant of the Yellow Sea and the eastern part of the East China Sea southward to Hong Kong.
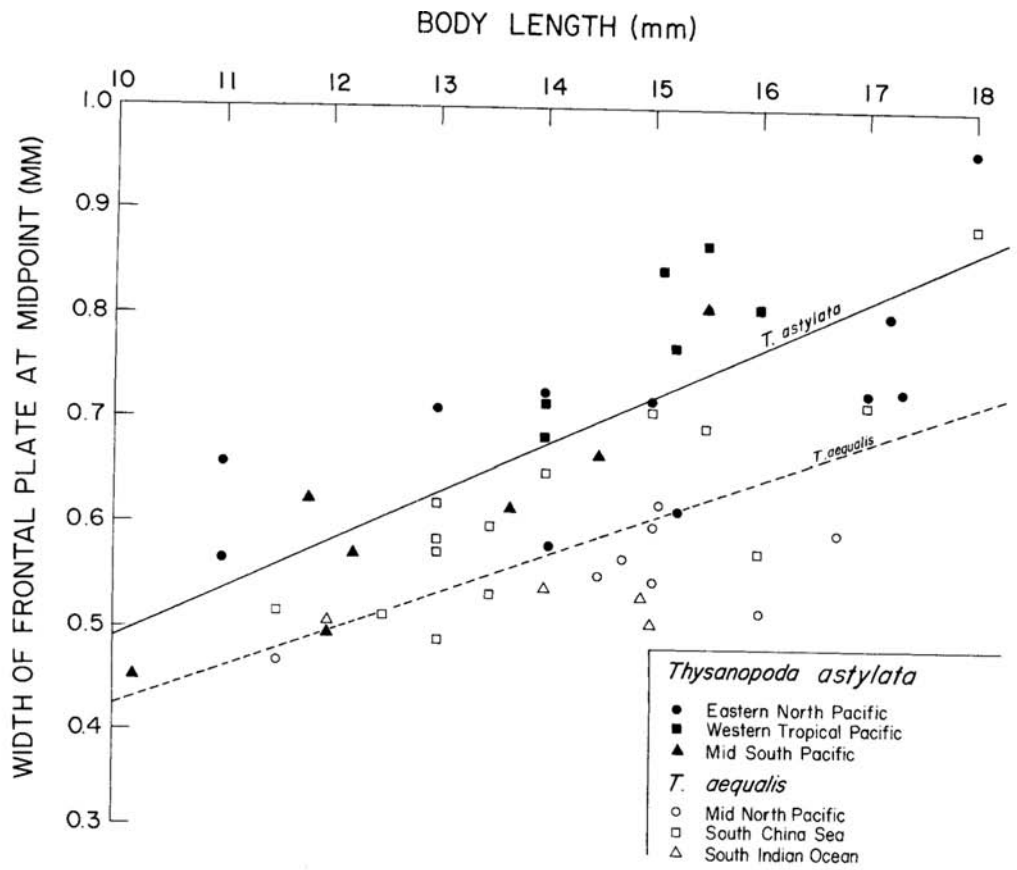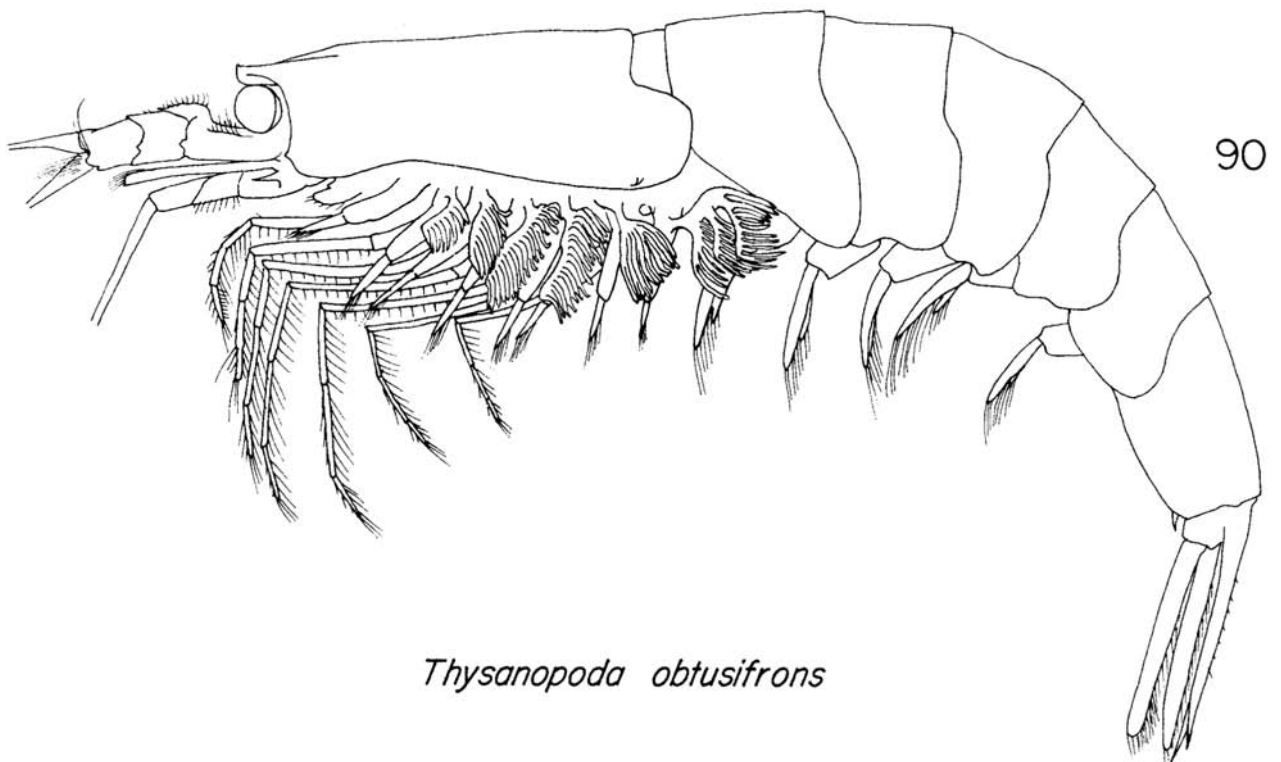
Figure 89. f) *T. aequalis, T. astylata*, values and regressions of width-of-frontal-plate vs. body length.

Thysanopoda obtusifrons

Figure 90. *Thysanopoda obtusifrons*.

Pseudeuphausia latifrons (G.O. Sars, 1883)

Figs. 91, 121h

Euphausia latifrons G.O. Sars, 1883: 19; 1885: 95-97, pl. xvi, figs. 17-23. *Pseudeuphausia latifrons* Hansen, 1910: 103-106, pl. xv, fig. 1, a-d; Boden et al., 1955: 320-322, fig. 18. ?*P. colosii* Torelli, 1934: 9-10, figs. 6-9.

The above generic characters apply to both species. The differences between them are to be seen in the following comparison, after Wang and Chen:

	P. sinica	*P. latifrons*
Eye (cornea width/ body length)	1/23-1/24	1/18 - 1/22
Antennular peduncle, 1st segment	without spine on outer anterior margin	with such a spine
Carapace	without prominent median keel	with such a keel
Mandible	without palp	with a well-developed palp
Maxillule	with exopod	without exopod
Petasma, inner lobe	Distal end produced into large digitate process; spine-shaped process on outer side clearly larger than the ones on inner side and strongly curved.	Distal end triangular, not digitate; spine-shaped processes on outer side similar in size to the ones on inner side and scarcely curved (Fig. 121h).

Genus *Euphausia* Dana, 1852

Generic diagnosis:

Eye spherical, or nearly so, not constricted.

Maxilla with broad terminal segment and small exopodite.

Thoracic legs similar in structure, none conspicuously elongated. 6th leg similar in length to 5th. 7th and 8th legs rudimentary, consisting of short unjointed setose processes.

Petasma has no spine-shaped process; terminal process with heel-like lateral extension at base.
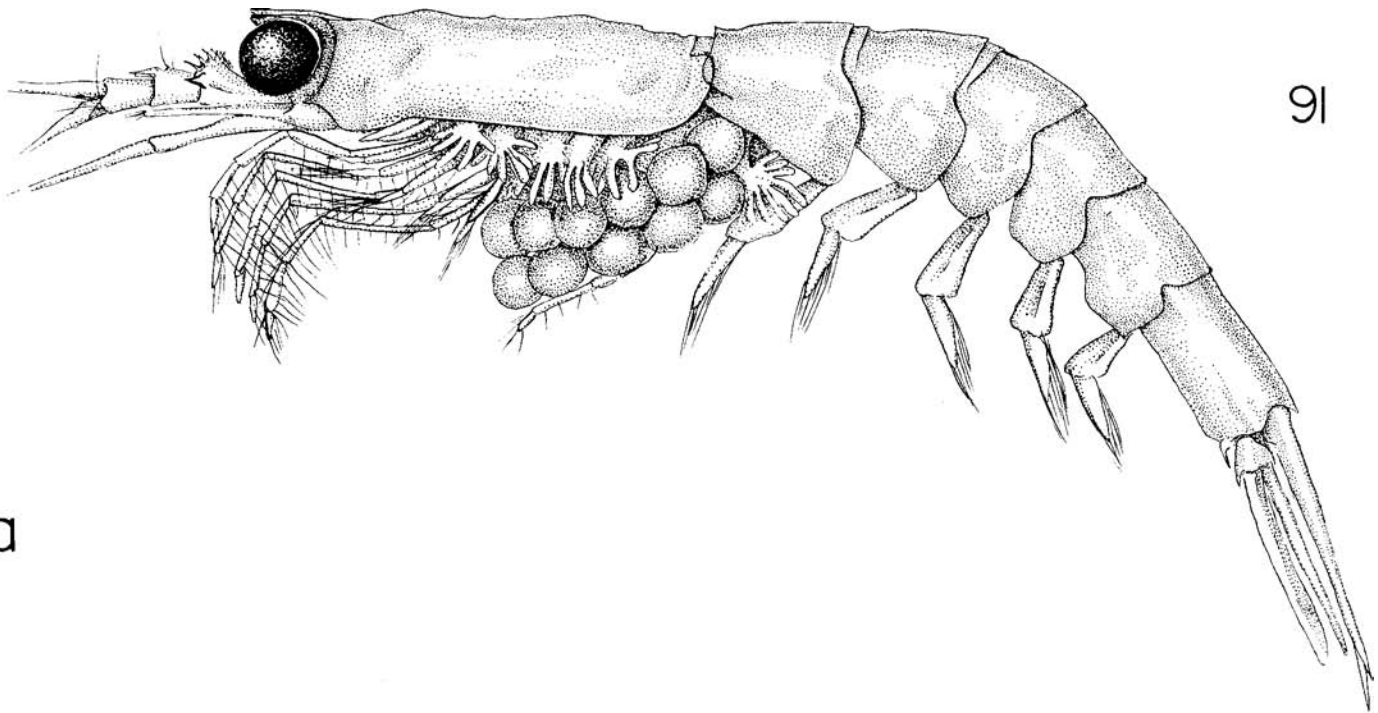
91

a
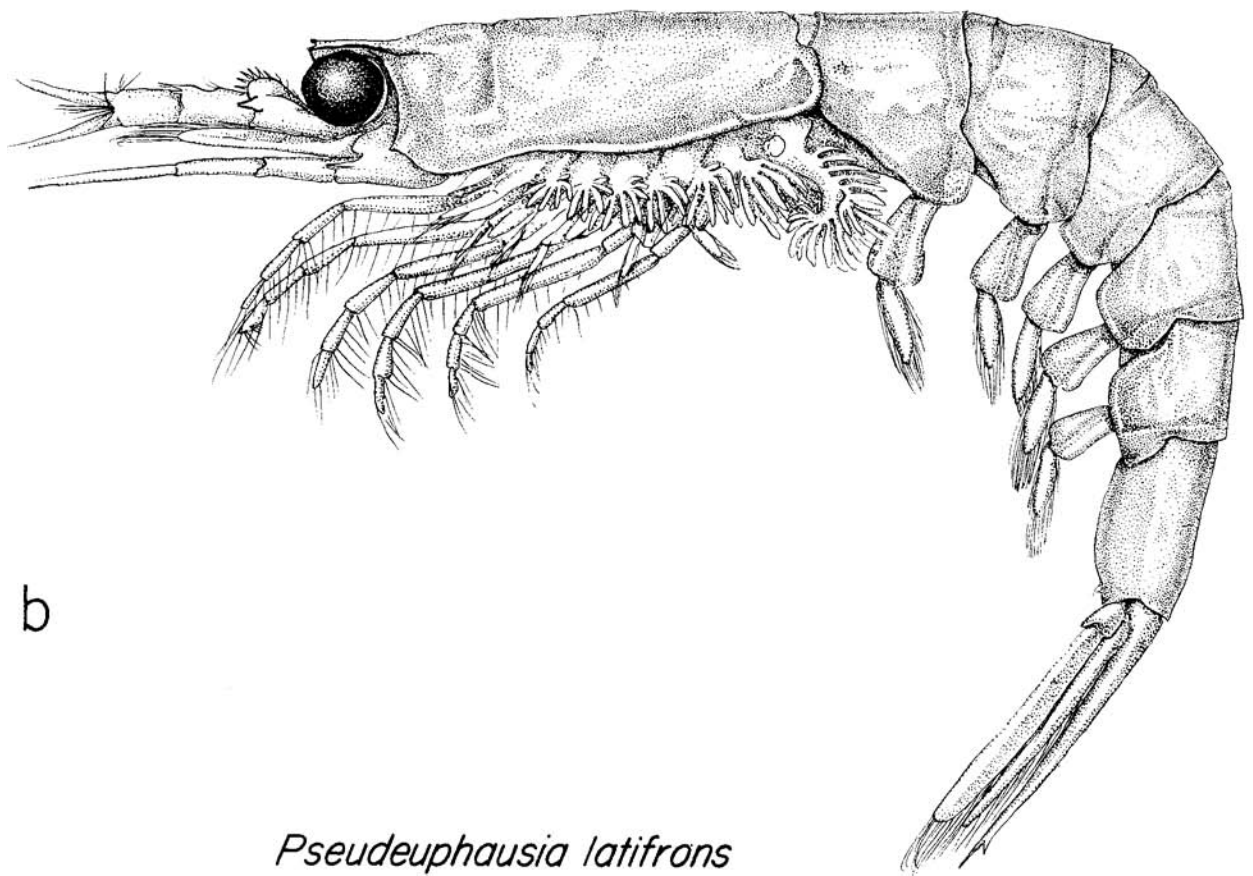
b

Pseudeuphausia latifrons

Figure 91. *Pseudeuphausia latifrons*, a) egg-bearing female; b) male.

The following attempt at a natural classification of *Euphausia* uses, where possible, multiple characters. This is the largest euphausiid genus, with 31 species. Hansen (1911) separated these species into four groups, using the number of lateral denticles on the carapace, together with the number of abdominal segments bearing dorsal spines. The spine on the 3rd abdominal segment has proved to be of limited value in assessing inter-specific relationships (e.g., in both *E. similis* and *E. vallentini* there are varieties with and without this spine); in the present classification it is used in groups II and III, but not in group I.

Hansen's group *a*, which, together with group *d*, was accepted by John (1936), is retained here as a natural group (I A). It was based on the presence of two pairs of lateral carapace denticles. Hansen's group *d*, based on the presence of dorsal spines on 3rd-5th abdominal segments, contained *triacantha* which appears most closely related to *similis* (of Hansen's group *b*). Of the species in group I only *triacantha* and *similis* show relationship to group III, both having a smooth anterior margin of the larval (calyptopis and furcilia) carapace but having the spine-like median posterior projection on the carapace of calyptopis and early furcilia stages as in group I.

Group II, the "Euphausia gibba group", shows no clear affinity with either group I or III. However, its members have smooth (not serrate or spined) anterior and posterior margins of the carapace in the calyptopis and early furcilia stages as in group III. Two of the four species have accessory teeth on the lateral process of the petasma. These teeth may be homologous with an accessory tooth on that process that is generally characteristic of group III.

A key to the 13 southeast Asian *Euphausia* species is also presented here. It relies largely upon morphological features which may be readily observed, particularly eye size and color[1], shape of lappet on 1st segment of antennular peduncle, and shape of rostrum of frontal plate.

However, I do not wish to deemphasize the established importance of petasma structure as an altogether reliable, absolute, specific character. Its value in assessing phylogenetic relationships is in question because, as a reproductive structure, it may be subject to accelerated modification (character reinforcement) when populations of sibling species come into contact with each other (e.g. in the copepod *Labidocera*, Fleminger, 1967).

<div align="center">Species Groups in the Genus Euphausia</div>

I. Rostrum long, acute;
    Eye reddish-brown in preserved specimens;
    Lappet on 1st segment of antennular peduncle with conspicuous, acute projection terminating as one, two, or many teeth;
    Petasma with lateral process a simple hook (without secondary sub-distal tooth).

    A. Two lateral carapace denticles on each side;
    No mid-dorsal abdominal spines; (This group corresponds to Hansen's group *a*, the same characters.)

        1. Lappet bifurcate (simple in male *recurva): brevis, diomedeae, mutica, recurva.*

        2. Lappet pectinate (comb-like): *exima, americana, krohnii.*

    B. One lateral carapace denticle on each side;
    With mid-dorsal abdominal spine on one or all of 3rd, 4th and 5th segments, except in *E. fallax* and *E. similis* variety *similis* where 3rd segment extends postero-dorsally as short, smoothly convex cover for anterior edge of 4th segment.

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[1]Eye color is black in all freshly caught euphausiids, but after preservation the pigment bleaches more readily to brown in groups I and II than in III (after a matter of months, more rapidly in alcohol than in formalin and in light than in dark).

1. Lappet a simple tooth: *gibboides, fallax, sanzoi.*

2. Lappet with 2 or more distal teeth.

    a. With post-ocular spine: *longirostris, spinifera, hanseni.*

    b. Without post-ocular spine: *similis, triacantha.*

II. Rostrum acute, medium-short;
Eye small, reddish-brown in preserved specimens;
Lappet a simple, acute, forward-directed process;
3rd abdominal segment with mid-dorsal posterior spine;

    A. Petasma with lateral process a simple hook: *hemigibba, gibba.*

    B. Petasma with lateral process having small pair of secondary spines at distal curvature: *pseudogibba, paragibba.*

III. Rostrum short and obtuse, or lacking (except in *superba* and *crystallorophias*, where it is acute);
Eye blackish-brown in preserved specimens;
Lappet simple, either with very short projecting tooth, or rounded distally.
Lateral process of petasma with secondary tooth on outer curvature (except in *pacifica-nana* and *superba*);

    A. 3rd abdominal segment with mid-dorsal posterior spine: *mucronata, lamelligera, distinguenda, sibogae.*

    B. 3rd abdominal segment extends postero-dorsally as short, smoothly convex cover for anterior edge of 4th segment: *tenera.*

    C. 3rd abdominal segment does not extend postero-dorsally (except in some "spined" *vallentini): pacifica, nana, lucens, frigida, superba, crystallorophias, vallentini.*

Key to Euphausia Species Occurring in Southeast Asian Waters

1a. Rostrum acute, medium-to-long;
Eye reddish-brown in preserved specimens;
Lateral process of petasma is a hook without secondary tooth;
Lappet with conspicuous acute (simple or bifid) projection.

  2a. Lappet bifid (except in male *recurva*);

  Eye medium-sized (carapace length/eye width, 5.0 to 6.2);

    3a. Two marginal or sub-marginal denticles on each side of carapace.

      4a. 2nd segment of antennular peduncle *without* conspicuous sub-dorsal anterior spines; lappet low in profile extending forward at angle of about 30° with horizontal . . . *mutica*

      4b. 2nd segment of antennular peduncle *with* conspicuous acute or nearly acute spine or spines at sub-dorsal anterior margin; lappet high, at angle of >45° with horizontal.

        5a. No spine on inner sub-dorsal anterior margin of 2nd segment of antennular peduncle; pleuron of 5th abdominal segment ends posteriorly in acute angle . . . *brevis.*

        5b. Spine present on inner (as well as outer) anterior margin of 2nd segment of antennular peduncle; pleuron of 5th abdominal segment has rounded posterior margin.

          6a. Lappet is vertical or even backward curving, bifid in female only . . . *recurva.*

          6b. Lappet is somewhat anteriorly directed, bifid in both sexes . . . *diomedeae*

    3b. One lateral carapace denticle on each side . . . *similis*

2b. Lappet simple, acute;

Eye large or small (not of medium size).

    7a. Eye large (carapace length/eye width, < 4.6).

        8a. With mid-dorsal posterior spine on 3rd abdominal segment ... *sanzoi*

        8b. Without spine on 3rd abdominal segment ... *fallax*

    7b. Eye small (carapace length/eye width, > 6.3).

        9a. Frontal plate with humped keel ... *paragibba*

        9b. Frontal plate with low keel, scarcely convex in lateral view.

            10a. Petasma with terminal and proximal processes slender, terminal process splitting into 2 teeth or hooks distally, median lobe extending well beyond lateral process.

                11a. Petasma with tip of proximal process recurved as hook; 3rd segment of antennular peduncle with keel which drops off abruptly posteriorly ... *pseudogibba*

                11b. Petasma with proximal process ending in straight plate, not hooked; 3rd segment of antennular peduncle with keel which merges smoothly, posteriorly, with dorsal margin of segment ... *hemigibba*

            10b. Petasma with terminal process short, stout, simple, and with proximal process extending beyond end of median lobe and lateral process extending almost to end of lobe ... *gibba*

1b. Rostrum short or lacking;

Eye blackish-brown in preserved specimens;

Lateral process of petasma bears small secondary tooth on outer curvature;

Lappet low and short, barely angular (in male *tenera*) to rounded.

12a. Mid-dorsal spine on 3rd abdominal segment ... *sibogae*

12b. No spine on 3rd abdominal segment ... *tenera*

<div align="center">

Euphausia mutica Hansen, 1905

Figs. 92, 120a

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E. mutica Hansen, 1905b: 14-15 (*partim*); 1910: 93-94, pl. xiv, fig. 1, a-d; Boden et al., 1955: 326-328, fig. 20.

Eye: Spherical, medium sized, diameter/carapace length is 1/5.6 ($\pm$ 0.3).

Antennular peduncle: Lappet on 1st segment bifid, low and forward-directed. Viewed from side, dorsal surface of lappet appears straight, but posteriorly, just anterior to eye, it angles downward. (This angle is not conspicuous. It may be clearly seen if specimen is slightly rotated so that ventral surface of specimen is tilted barely upward.)

   2nd segment usually without processes, on some large specimens a low hump, sometimes with nub of forward-directed spine, is present at distal outer margin. 3rd segment bears low, rounded keel.

Rostrum: Acute, almost straight, extending to forward limit of eyes.

Carapace: Gastric region a low dome, without characteristic shape. There are two pairs of lateral carapace denticles.

Abdomen: No dorsal spines or specific features.

Petasma: Trunk of terminal process nearly straight, distal portion curved with tapering acute ending. A small distally-directed spine is situated on concave margin of process, near tip. Proximal process curved, terminating in rounded plate which has heel-like process on inner margin directed toward origin of process. Median lobe has acute tip, curving so as to be directed back toward origin of lobe.

Length: 7-12 mm.

Remarks: Lappet on 1st antennular segment is lower and more anteriorly directed than in *E. brevis, E. diomedeae* and *E. recurva*. Obtuse angle at posterior limit of lappet just in front of eye, may be clearly seen with practice.

Adults of *E. mutica* are smaller in Indo-Australian region than in subtropical and temperate latitudes.

<div align="center">

Euphausia brevis Hansen, 1905

Figs. 93, 120b

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E. brevis Hansen, 1950b: 15-16; 1912: 239-241, pl. viii, fig. 1, a-g; Boden et al., 1955: 328-330, fig. 21.

Eye: Spherical, medium sized, diameter/carapace length is 1/6.0 ($\pm$ 0.3), hence smaller than in *mutica, recurva* and *diomedeae*.

Antennular peduncle: 1st segment bears slender distally-bifurcate lappet reaching upward and forward at angle of 60-70°. Occasionally lappet is nearly vertical, though the paired acute tips may bend somewhat forward over part of 2nd peduncular segment.

2nd segment bears single forward-directed spine at anterior margin. This spine is straight, triangular, acute and situated at outer dorsal edge of segment. 3rd peduncular segment with low, poorly-defined dorsal keel.

Rostrum: Straight, acute, reaching just beyond anterior limit of eyes.

Carapace: Gastric area domed, without characteristic shape. With two pairs of lateral denticles.

Abdomen: No dorsal spines. Pleura on 5th segment terminate acutely at posterior-lateral limits.

Petasma: Trunk of terminal process tapering and straight, with slender, slightly-curved tip. Base of curved tip is point of origin for slender, straight, distally-directed spine which does not reach to curved tip of process, but appears to be nearly parallel to the barely curving tip.

Proximal process curved through 90°, ending as flat, rounded oblong plate which appears acute in lateral view. An obliquely-pointing tooth-like heel is situated at base of this plate.

Length: 8-10 mm.

Remarks: *E. brevis* is smaller than *E. diomedeae, E. mutica* and *E. recurva*. Also, eye is relatively smaller than in those species. The straight acute spine on 2nd peduncular segment, and acute posterior endings to pleura of 5th abdominal segment are characteristic.

Euphausia recurva Hansen, 1905
Figs. 94, 120c

E. recurva Hansen, 1905b: 13-14; 1912: 233-235, pl. vii, fig. 3, a-n; Boden et al., 1955: 324-326, fig. 19.

Eye: Spherical, medium in size, diameter/carapace length is 1/5.5 ($\pm$ 0.3)

Antennular peduncle: Lappet on 1st segment sexually dimorphic. In males it is a vertical or slightly reflexed process, the base of which is half as wide as antennular segment, narrowing distally, and hollowed anteriorly. It is long, reaching to upper margin of eye. In females, lappet is a slightly shorter vertical process, also half as wide as antennular segment, forked distally into two acute parts, the inner part being the longer. It is less conspicuously hollowed anteriorly than in the male.

2nd segment in both sexes with short, forward-directed conical process on outer distal margin and longer, more acute process on inner distal margin. 3rd segment bears high keel, notched anteriorly so as to form an anteriorly-directed dorsal tooth.

Rostrum: Acute, straight, extending to forward limit of eyes.

Carapace: Gastric region a low dome, without any characteristic shape. There are two pairs of lateral carapace denticles.

Abdomen: No dorsal spines or specific features.

Petasma: Trunk of terminal process straight, tip curved beyond origin of slender straight spine that extends distally to underside of curving top of process. Proximal process slightly curved throughout its length, broadening distally and terminating as truncated plate that is indented or cleft in large specimens.

Length: 10-14 mm.

Remarks: Lappet on 1st antennular segment is broader and higher than in *E. brevis*; outer branch of forked tip of this lappet is shorter than inner branch in *E. recurva* (female) but outer branch is the longer in *E. diomedeae*. In *E. brevis* the two branches are of equal length. Eye is somewhat larger in *E. recurva* than in *E. brevis*. The shape of keel on 3rd antennular segment distinguishes *E. recurva* from *E. diomedeae, E. brevis* and *E. mutica*.

Specimens of this species found in the tropics are smaller than those from higher latitudes.
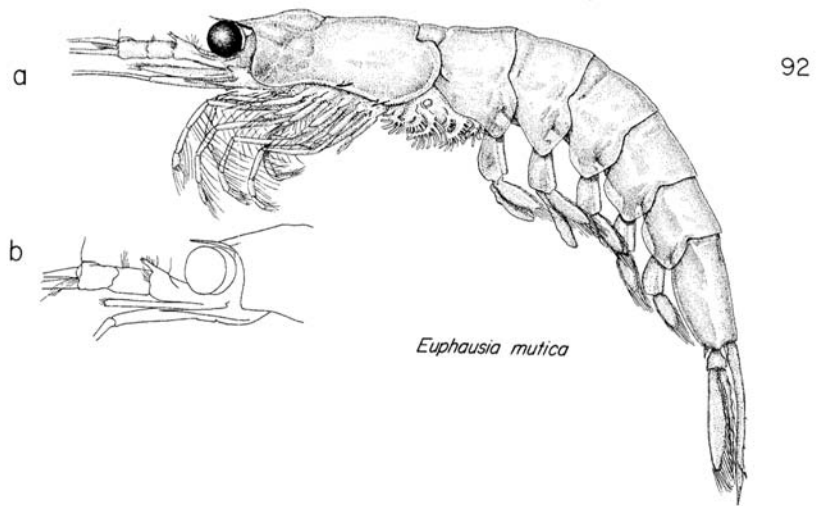
Figure 92. a) *Euphausia mutica*, b) peduncles of antennae and head region.
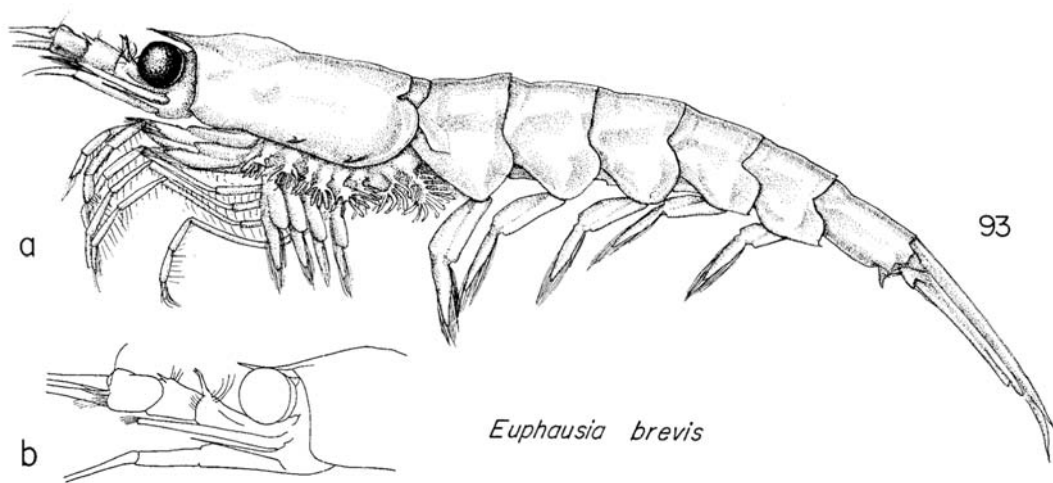
Figure 93. a) *Euphausia brevis*, b) peduncles of antennae and head region.
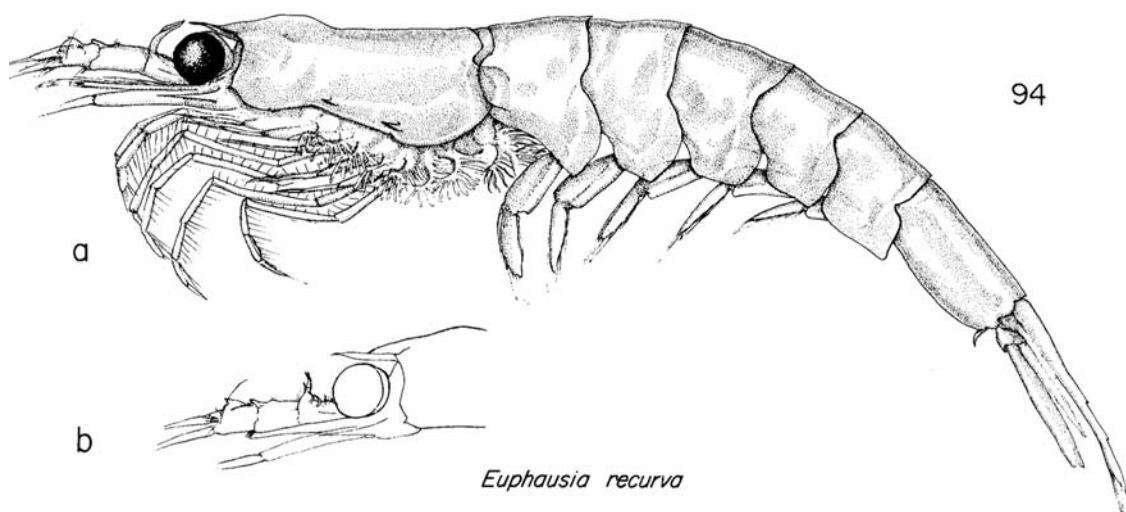
Figure 94. a) *Euphausia recurva*, male; b) peduncles of antennae and head region of female.

Euphausia diomedeae Ortmann, 1894

Figs. 95, 120d

E. diomedeae Ortmann, 1894: 102, pl. 1, fig. 3; Hansen, 1910: 91–93, pl. xiii, fig. 4, a-e; 1912: 235, pl. vii, fig. 4a; Boden et al., 1955: 330–331, fig. 22. *E. mutica* Hansen, 1905b: 14–15 (*partim*) (*fide* Hansen, 1910: 91–93).

Eye: Spherical, medium in size, diameter/carapace length is 1/5.5 (± 0.3).

Antennular peduncle: Lappet on 1st segment extending more upward than forward, at an angle of about 50°. Tip of lappet bifid and bending anteriorly. 2nd segment bears dorso-lateral spine-like process on both inner and outer margins. These arise from a distal depression on dorsal surface of segment. Process on outer margin appears the more sturdy of the two, curving upward and forward. 3rd segment bears low rounded keel.

Rostrum: Acute and almost straight, extending about to anterior limit of eyes.

Carapace: Gastric region domed, sometimes peaked, without any characteristic shape. Two pairs of lateral carapace denticles.

Abdomen: No dorsal spines or specific features.

Petasma: Terminal process straight but with curved hook-like end, more slender than stem of process. At base of curved part is small, straight, distally-directed spine. Proximal process as long as or longer than terminal process, ending in flattened plate. This plate extends out beyond an obliquely-directed spine.

Length: 10–16 mm.

Remarks: Angle (ca. 50° with horizontal) of lappet on 1st segment of antennular peduncle is characteristic of the species. The short, stout, curved, tusk-like shape of outer spine on 2nd antennular segment also stands out strongly as a specific character. This spine is longer than in *E. recurva*, more curved and stout than the acute straight spine in same place on *E. brevis*. Eye is larger than in *E. brevis*. Distal portions of terminal and proximal processes of petasma are useful in specific determination when antennular peduncle is damaged.

Occasional specimens of this species have frontal plate expanded laterally over the eyes, having the effect of shortening the rostrum (cf. Hansen 1912, pl. vii, fig. 4a).

Euphausia similis G.O. Sars, 1883 Figs. 96, 120e

E. similis G.O. Sars, 1883: 13; 1885: 79–80, pl. xiii, figs. 1-6; Hansen, 1913: 29, pl. iv, fig. 3, a-3; John, 1936: 233–236, figs. 24-26; Boden et al., 1955: 337–339, fig. 26. E. *similis* var. *crassirostris* Hansen, 1910: 94, pl. xiv, fig. 2, a-c.

Eye: Spherical, medium-small, diameter/carapace length is 1/6.1 (± 0.2).
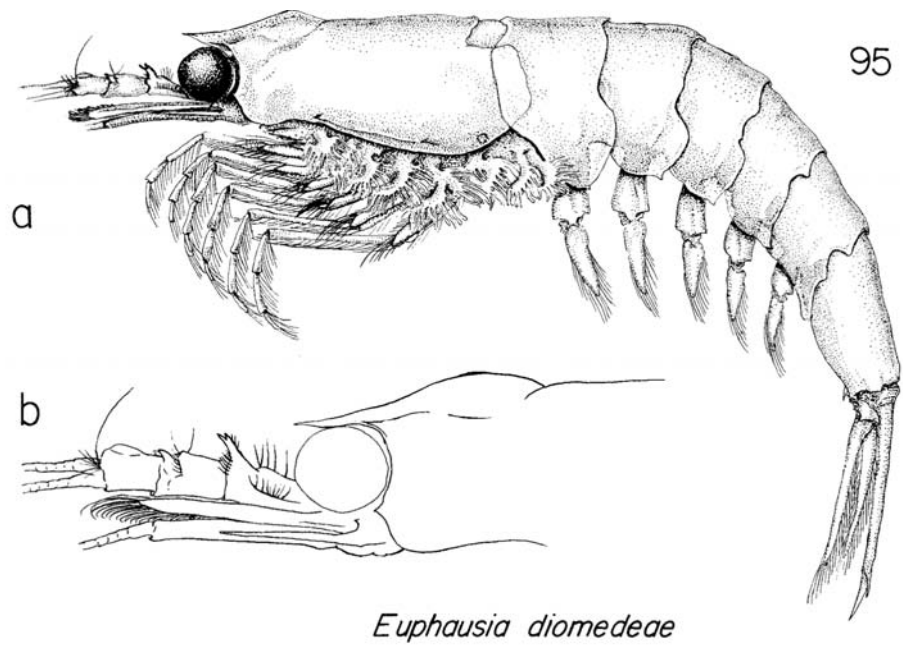
Figure 95. a) *Euphausia diomedeae*, b) peduncles of antennae and head region.
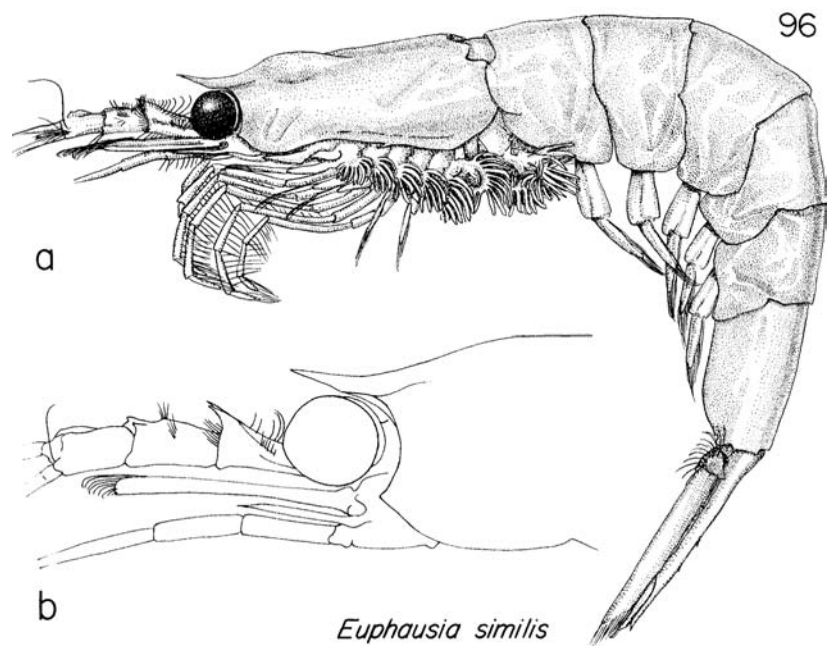
Figure 96. a) *Euphausia similis*, b) peduncles of antennae and head region.

Antennular peduncle: 1st segment bears strong dorsal lappet, projecting over proximal part of 2nd segment at an angle of 30° with the horizontal. Tip of lappet bifurcate, inner tooth being longer than outer. Anterior part of 2nd segment bears keel-like teeth at inner and outer dorsal-lateral angles, inner one being the larger. 3rd segment bears smoothly rounded dorsal keel.

Rostrum: Acute, reaching about to anterior limit of eye, strongly keeled as is frontal plate. In some specimens (variety *crassirostris*) the keel on frontal plate is elevated and convex.

Carapace: Gastric region a low smoothly-rounded dome. There is one pair of lateral denticles.

Abdomen: Mid-dorsal part of 3rd segment expanded posteriorly as convex covering for short portion of 4th segment (as in *E. tenera*). Variety *armata*, which possesses mid-dorsal spine on 3rd segment, is known only from sub-Antarctic regions.

Petasma: Terminal process nearly straight and terminates in short subacute hook. At base of hook, trunk of terminal process expanded as small rounded plate, projecting distally toward the curved tip of terminal hook. Proximal process bends at nearly a 90° angle at its midpoint, and distal half broadens before terminating acutely. Lateral process a simple hook.

Length: 22–26 mm.

Remarks: Conspicuously keeled rostrum and frontal plate are characteristic. Shape of processes on first two segments of antennular peduncle distinguish *E. similis* from other large *Euphausia* species of Indo-Australian seas.

Euphausia sanzoi Torelli, 1934
Figs. 97 a-f, 121 c-e

E. sanzoi Torelli, 1934: 7–8, figs. 2-5; Weigmann, 1970: 19, fig. 10.

Eye: Large, diameter/carapace length is 1/4.3 ($\pm$ 0.15).

Antennular peduncle: Each of the three segments has dorsal keel or process. Processes on first two segments are characteristic of all three species of "E. gibboides species group": 1st segment has simple upward and forward-directed pointed lappet, 2nd has rounded distal lobe extending forward over part of 3rd segment, 3rd has anteriorly-notched dorsal keel as in *E. gibboides*, whereas this keel has no acute notch in *E. fallax*.

Rostrum: Acute or pointed in lateral view, curving barely upward (at angle of ca. 2–4°) as it extends forward to midline or nearly to distal limit of eye.

Carapace, dorsal part: Gastric region domed, with vestige of a bump (more prominent in the juvenile) just posterior to and equal in height to rounded dorsal crest on gastric dome. This shape is characteristic.

Figure 97. a) *Euphausia sanzoi;* b) head region, South China Sea specimen; c) head region, western Indian Ocean specimen; d) antennular peduncle South China Sea specimen; e) keel on 3rd segment of antennular peduncle, western Indian Ocean specimen; f) keel on 3rd segment of peduncle, South China Sea specimen. g) *E. fallax*, head region, h) 3rd, 4th abdominal segments, i) keel on 3rd segment of antennular peduncle.

Abdomen: Small, slender, mid-dorsal posterior spine on 3rd segment.

Petasma: Terminal process divides into two finger-like parts distally: the more distal one curved, the other shorter and more blunt. Median lobe has two triangular processes halfway along its inner edge extending towards inner lobe. Outer (setiferous) lobe has 7 setae terminally and 1–3 on outer basal edge.

Length: 15–18 mm.

Remarks: *E. sanzoi*, together with *E. gibboides* and *E. fallax* forms an "E. gibboides group" of closely related species.

E. gibboides, which lives in the north and western Pacific and in the Atlantic, has the terminal process of the petasma ending in a simple curved finger. The median lobe of the petasma bears a single triangular process like *fallax* (*sanzoi* has two), situated proximally from hooked lateral process. *E. gibboides* in the Pacific has 5 setae on outer edge of outer lobe, near its base, and mature specimens are 18–25 mm. 16–17 mm specimens from the eastern tropical Atlantic had 3 setae on outer basal edge of outer lobe of petasma (in general, within a species, the smaller specimens have fewer).

E. sanzoi has heretofore been reported only from the western Indian Ocean (Torelli, 1934; Weigmann, 1970, 1974b; Brinton and Gopalakrishnan, 1973). It has been regarded as so similar to *fallax* that its recognition as a separate species has rested, in part, on its presumed separate region of distribution. Mature specimens are 15–17 mm, as in *fallax*.

The differences between *sanzoi* from the western Indian Ocean and from the East Indies are small and inconsistent, hence possibly insignificant. They are best seen in a comparison:

1. Dorsal keel on 3rd segment of antennular peduncle has its dorsal edge somewhat less convexly curved in *sanzoi* from the Indian Ocean (Fig. 97 e, f).

2. Tip of lappet on 1st segment of antennular peduncle is directed more forward in *sanzoi* from the East Indies (Fig. 97 b).

3. Rostrum is usually, but not always, more up-curved in the East Indian population (Fig. 97 b, c).

4. A very small dorsal bump is usually situated just *behind* rounded dorsal crest of gastric region of carapace in the East Indian specimens (Fig. 97 b). In the Indian Ocean *sanzoi* this bump is situated *on* dorsal crest (Fig. 97 c) (as in *gibboides*).

5. Outer lobe of petasma on *sanzoi*, from both geographical regions, usually has as many as 3 small setae on its outer edge (as figured by Torelli, 1934; and by Weigmann, 1970). (*Gibboides* has as few as 3 on 16 mm specimens from Eastern Tropical Atlantic, and as many as 5 on 25 mm specimens from the California Current.)

Evidently by chance, Hansen selected only *fallax* from his Philippines samples for purposes of petasma examination. Grossly, the two species are alike. A re-examination of Hansen's sample from southern Luzon shows *fallax* to outnumber *sanzoi* by 288:61.

Euphausia fallax Hansen, 1916

Figs. 97 g-i, 121 f, g

E. fallax Hansen, 1916: 645–646, pl lxxxiii, fig. 1, a-d.

Eye: Large, diameter/carapace length ratio as in *E. sanzoi* (*ca.* 1/4.3).

Antennular peduncle: 1st segment has simple, strong, pointed lappet, somewhat more forward-directed than in *E. sanzoi;* 2nd segment has rounded distal lobe; 3rd has dorsal distal

keel, margin of which is rounded and somewhat indented anteriorly but not notched as in *sanzoi*.

Rostrum: Acute, curving slightly upward over eyes, extending beyond midpoint of eyes.

Carapace: Gastric region domed, with vestige of bump (more prominent in the juvenile, as also in *sanzoi*) situated on or just posterior to apex of gastric dome. One pair of lateral denticles.

Abdomen: 3rd segment without spine but extended posteriorly as a mid-dorsal covering over a small portion of 4th segment.

Petasma: Terminal process cleft into 3 processes distally. Middle process longest and innermost shortest. Median lobe has single triangular process below lateral process, extending towards inner lobe. Outer lobe has 7 terminal setae and one or two on outer basal edge.

Length: 15–17 mm.

Remarks: Hansen's (1916) description of *fallax* appears to be in error in two respects. I have examined his specimens from the type locality in the Philippines, and the terminal process of male petasma is indeed trifid as figured, the critical character. However, the median lobe of *fallax* possesses one triangular process proximal from lateral process, though Hansen described it as having none. Further, there is *no* dorsal spine on 3rd abdominal segment. Hansen noted that there were spined specimens in the sample, but did not recognize them as a different species. (*Sanzoi* was described 18 years later by Torelli.)

The most useful character for separating the two species is the shape of dorsal keel on 3rd segment of antennular peduncle. In *fallax* it is more or less rounded distally (Fig. 97 i), not notched as in *sanzoi* (Fig. 97 e, f).

Euphausia pseudogibba Ortmann, 1893

Figs. 98 a, b, 121 h,i

E. pseudogibba Ortmann, 1893: 12, taf. 1, fig. 6; Hansen, 1910: 97–99, pl. xvi, fig. 4 a-e; Boden et al., 1955: 340–342, fig. 28.

Euphausia hemigibba Hansen, 1910

Figs. 98 c, 121 j

E. hemigibba Hansen, 1910: 100, pl. xiv, fig. 5 a-f: Boden et al., 1955: 342–344, fig. 29.

Euphausia paragibba Hansen, 1910

Figs. 98 d, 121 k, 1

E. paragibba Hansen, 1910: 100–101, pl. xiv, fig. 6 a-d; Boden et al., 1955: 339–340, fig. 27.

Euphausia gibba G. O. Sars, 1883

Fig. 98 e, 121 m

E. gibba G. O. Sars, 1883: 17–18; 1885: 91–93, pl. xiv, figs. 1-8; Hansen, 1912: 244–246, pl. VIII, fig. 2 a, b.

Eye: Spherical, small, diameter/carapace length is 1/6.8 ($\pm$ 0.3) in all 4 species of "Euphausia gibba group".

Antennular peduncle: Lappet on 1st segment an acute tooth, upward and forward-directed extending above proximal part of 2nd segment. Shape of lappet shows no clear species specificity within the species group.

2nd segment bears no processes. 3rd segment with low, dorsally-convex keel that, anteriorly, is either rounded or bears a minute tooth-like projection (not species specific). In *E. pseudogibba* this keel drops sharply away posteriorly, tending almost to truncate the posterior margin; this distinguishes *E. pseudogibba* from the 3 other species, in which posterior margin of keel more gradually merges with dorsal surface of 3rd segment, in lateral view.

Rostrum: This structure shows species specificity though occasional specimens depart from the diagnosis.

E. pseudogibba: Rostrum upturned, rarely extending to anterior margin of eye. Viewed laterally, frontal plate flat or with a low keel behind rostrum.

E. hemigibba: Rostrum upturned, rarely extending to anterior margin of eye. Viewed laterally, frontal plate not keeled behind rostrum.

E. paragibba: Rostrum barely upturned, usually extending to anterior margin of eye. Viewed laterally, frontal plate strongly humped with a convex keel behind rostrum.

E. gibba: Rostrum barely upturned, usually extending to anterior margin of eye. Viewed laterally, frontal plate not humped behind rostrum.

Carapace: Gastric region a low dome in all 4 species. There is a single pair of lateral denticles.

Abdomen: 3rd segment bears conspicuous mid-dorsal spine, not species specific in shape.

Petasma: This structure shows clear differences among the 4 species. *E. gibba* differs most distinctly from the other 3.

E. pseudogibba: Tip of terminal process notched, the longer of the two resulting teeth slightly curved. Proximal process considerably longer than terminal and tip strongly curved or reflexed as a hook. Distal part of median lobe long, straight and slender compared with base of lobe. Lateral process with two minute sub-distal spines and vestige of a 3rd.

E. hemigibba: Tip of terminal process hooked, with opposing, distally-directed tooth at base of hook. Proximal process closely paired with terminal, and barely longer, ending distally as an oblong, obliquely-twisted plate, with finely serrated inner margin. Median lobe gradually narrows distally and bears simple lateral process.

E. paragibba: Terminal process long, slender, with short distally-directed tooth-like process at base of curved tip. Proximal process longer, and curved through 35-45° distally. Median lobe narrows sharply above its base but broadens distally into lobe-like ending. Lateral process not an evenly curving hook, but bears a pair of short spines arising from a depression in convex margin of process.

Euphausia pseudogibba

E. pseudogibba

E. hemigibba
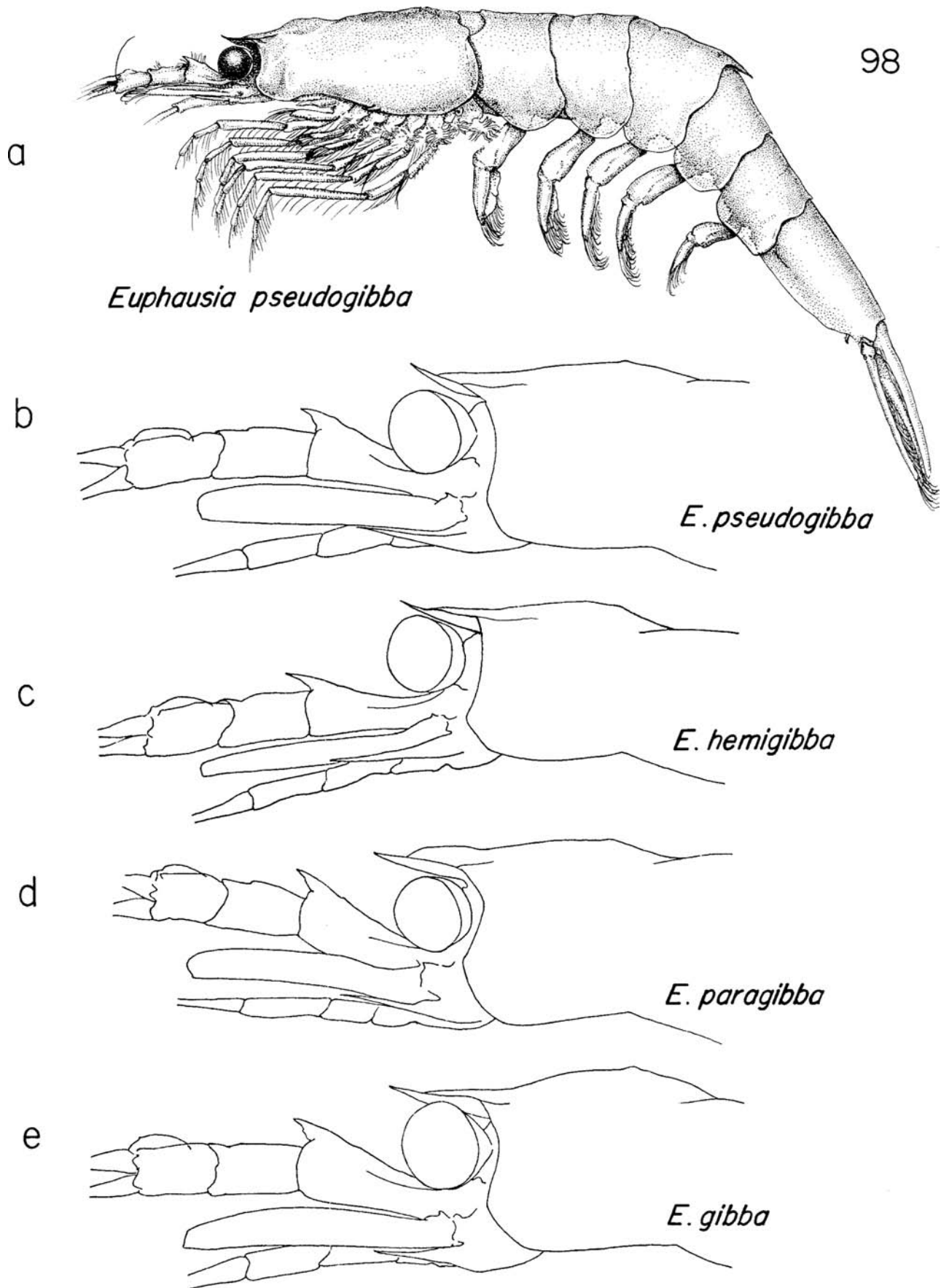
E. paragibba

E. gibba

Figure 98. a) *Euphausia pseudogibba.* Peduncles of antennae and head region, b) E. pseudogibba, c) *E. hemigibba*, d) *E. paragibba*, e) *E. gibba.*

E. gibba: Terminal process extremely short and stout, tapering to blunt, slightly-curving tip. Proximal process stout, long, and pointed, distal half curving in gentle arc. Median lobe much reduced, terminating in weak, distally-curving finger. Lateral process simple, stout and sharply curved.

Length: All 4 species are 9-14 mm as adults. *Hemigibba* and *paragibba* tend to be larger than *gibba* and *pseudogibba.*

Remarks: Petasma is most reliable character. James (in press) has found specific differences among the thelyca, so females may now be reliably separated as to species. Dorsal keel on 3rd segment of antennular peduncle is particularly useful in distinguishing *pseudogibba.* Strongly humped frontal plate is characteristic of *paragibba.*

Euphausia sibogae Hansen, 1908

Figs. 99, 120g

E. sibogae Hansen, 1908c: 158; 1910: 101-103, pl. xiv, fig. 7, a-d; Sebastian, 1966: 244-245, fig. 11.

Eye: Spherical, medium-small, carapace/diameter ratio is 4.7 ($\pm$ 0.2) for specimens in Java to Philippines region, and 5.35 ($\pm$ 0.1) for Arabian Sea-Bay of Bengal specimens.

Antennular peduncle: 1st segment bears low rounded lobe, barely extending over base of 2nd segment. 2nd segment with upper distal outer angle produced as very low rounded process; in large specimens from the northern Indian Ocean this process is more ridge-like, directed obliquely upward and forward. 3rd segment with very low simple keel.

Rostrum: Short, obliquely triangular, extending to midpoint of eye.

Carapace: Gastric area angularly elevated, higher in the northern Indian Ocean specimens than in those from the Archipelago. There is one pair of lateral denticles.

Abdomen: 3rd segment bears a stout mid-dorsal tooth.

Petasma: Terminal process heavy, tapering to narrow, curved tip which appears acute in lateral view. Proximal process does not reach as far as end of terminal process; basal half thick and curved, middle portion narrows, distal half broadens, and terminal part tapers to acute, inward-directed end. Median lobe tapers to rounded end, and lateral process is strongly hooked, with acute secondary tooth on convex margin at or beyond top of curvature. Setiferous lobe has 6 distal setae and one sub-distal with 2-3 smaller setae on outer margin, the larger specimens having the more outer setae.

Length: 8-11.5 mm.
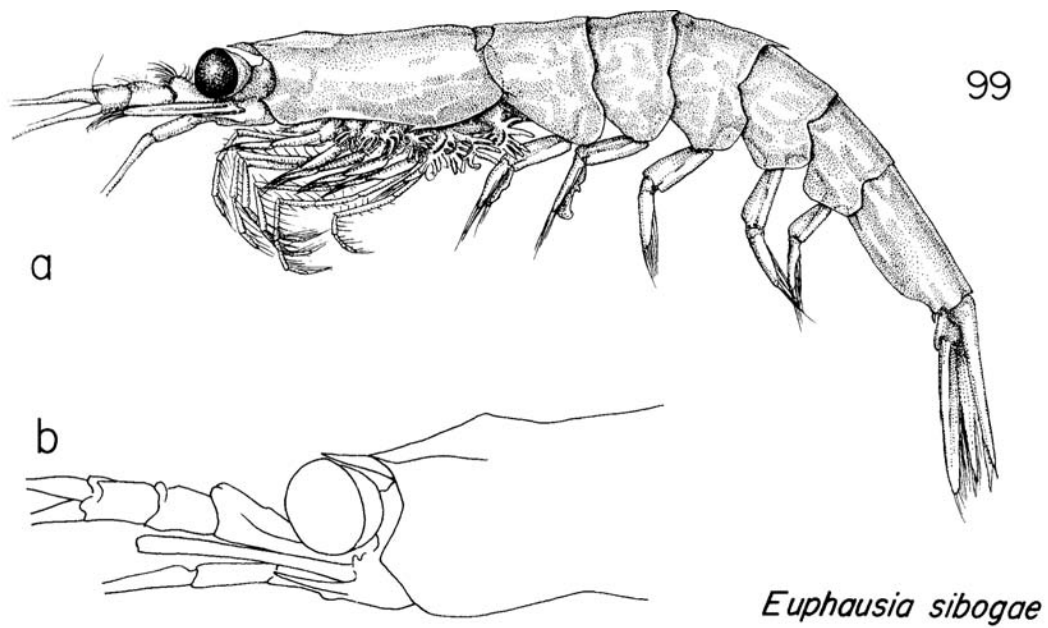
Figure 99. a) *Euphausia sibogae*, b) peduncles of antennae and head region.
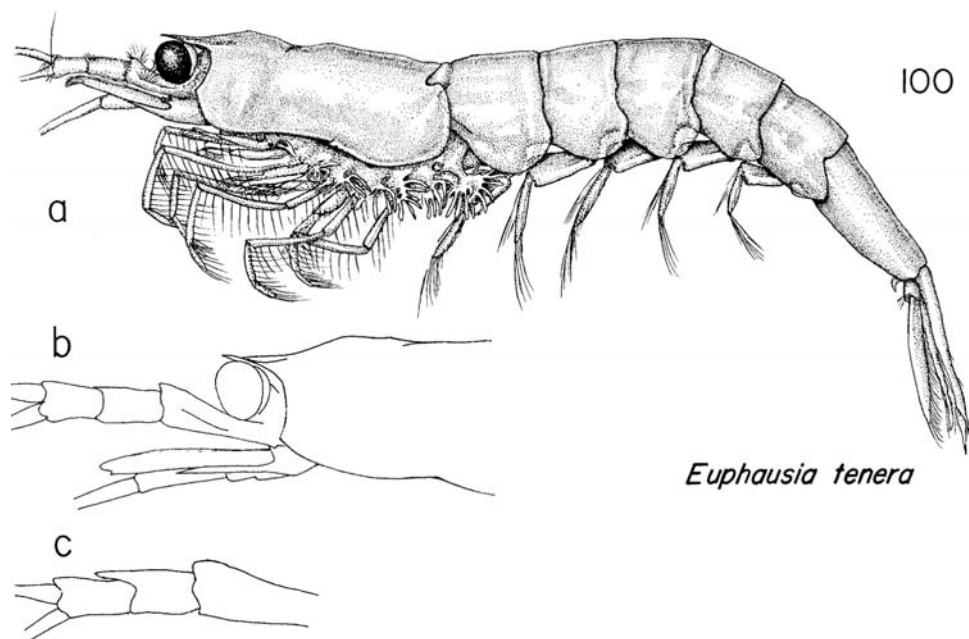
Figure 100. a) *Euphausia tenera*, b) peduncles of antennae and head region of female, c) antennular peduncle of male.

Remarks: *E. sibogae* is distinguishable from the "E. gibba group" by the somewhat angular shape of the gastric keel, the more heavily pigmented (blacker), somewhat larger eyes and by the rounded shape of anterior-dorsal process lappet on 1st antennular segment. It is easily separated from *E. tenera* because it possesses a spine on 3rd abdominal segment.

Sebastian (1966) raised a question as to whether the population in the northern Indian Ocean was *E. distinguenda* (described by Hansen, 1911, from the eastern Pacific) as it had been designated by Tattersall (1939), Brinton (1962a) and others, or whether it might be closer to *E. sibogae* (described by Hansen, 1908c, from north of Java). While retaining the name *E. distinguenda* for the Indian Ocean population, Sebastian pointed out that the petasma of his specimens resembled *E. sibogae*, particularly with respect to the shortness of the proximal process relative to that in *E. distinguenda* from the eastern Pacific. I now agree that the northern Indian Ocean form is more like the East Indian Archipelago form than like the eastern Pacific form. More correctly, it appears to be intermediate between the two, in all characteristics, including size (eastern Pacific form is 10–14.5 mm; northern Indian Ocean form is 9–11.5 mm; Archipelago specimens are 8–9 mm). I have here applied the name *sibogae* to the northern Indian Ocean form because that population appears to be at least in tenuous contact with the population of *sibogae* from the region of Java. Brinton and Gopalakrishnan (1973) discussed these populations only as an "E. distinguenda group".

<div align="center">

Euphausia tenera Hansen, 1905

Figs. 100, 120f

</div>

E. gracilis G. O. Sars, 1885: 89–91, pl. xv, figs. 12-23; (nec *E. gracilis* Dana, 1852: 644). *E. tenera* Hansen, 1905b: 9; 1910: 95–97, pl. xiv, fig. 3, a-e; Boden et al., 1955: 335–337, fig. 25.

Eye: Small, ovoid, barely higher than broad.

Antennular peduncle: In male, the anterior dorsal edge of 1st segment raised, rounded, but not extending forward over 2nd segment as a lappet; in female, raised dorsal part barely higher than in male, terminating anteriorly at an acute, rather than blunted angle, still not extending forward over 2nd segment.

In male, 2nd segment ends dorsally as thin, narrow lobe which overlaps 1/3 of 3rd peduncular segment. In female, lobe is shorter and more acute distally. 3rd segment bears no keel.

Rostrum: Short, with frontal plate obliquely triangular, rarely reaching to anterior limit of eye.

Carapace: Gastric dome low, not angularly humped. There is a single lateral denticle.

Abdomen: 3rd segment extends as rounded mid-dorsal cover over short portion of 4th segment.

Petasma: Trunk of terminal process nearly straight, with curved acute end. Proximal process has thick curved base and slender distal half, ending in 4-toothed comb. Opposite this comb is longer curved process or hook, at the base of which, on concave margin, is small process or spine. Lateral process bears acute secondary tooth on convex margin of curving hook-like end.

Length: 7–9 mm.

Remarks: Short rostrum, low gastric dome, and rounded or barely angular dorso-distal end to 1st antennular segment are characteristic, distinguishing *E. tenera* from other small-eyed *Euphausia* species (i.e. the "E. gibba group").

Generic diagnosis:

Eye two-lobed, with transverse constriction.

Mandibular palp very small.

Peduncles of first antennae more elongate and slender in female than in male.

Endopodite of first pair of thoracic legs (maxilliped) with terminal segment triangular-shaped, furnished with brush-like bristles on inner lateral margin.

Endopodite of second pair of legs very elongate with tuft of long straight apical bristles arising from terminal segment, or from both terminal and preceding segment.

7th thoracic endopod two-segmented in female, lacking in male. 8th leg a simple setose plate.

Eggs carried externally by female, attached to thoracic limbs by glutinous adhesive.

Petasma with spine-shaped process straight and upright, lateral process not hooked.

Five of the seven species of *Nematoscelis* occur in southeast Asian waters. Only the sibling pair *N. difficilis-N. megalops* are lacking, being confined to 35–45° zones bordering the tropical-subtropical regime occupied by the other five species of the genus.

Nematoscelis has been the subject of intensive study by Gopalakrishnan (1974, in press) in which both adults and larvae are treated. The key and descriptions included here largely derive from this work and from Hansen (1910, 1912) and Mauchline and Fisher (1969). Gopalakrishnan accepted the seven established species of the genus and described two forms, considered ecophenotypes, of *N. gracilis*. Both an "Old Form", based on Hansen's (1910) description of *Siboga* specimens, and a "New Form" (see distributions, Fig. 61 b) occur in the region of the present survey. However, references here to *N. gracilis* in waters of the Archipelago do not distinguish between the two forms, though "Old Form" predominates to the north of the equator and "New Form" to the south, according to Gopalakrishnan. The South China Sea population (Fig. 35) appears therefore to be of the "Old Form"; petasmas examined from that region substantiate Gopalakrishnan's findings.

The species of this genus lack specific antennular structures and are difficult to distinguish. The eyes are similar in shape, except for *N. tenella* in which the upper lobe is distinctly larger than the lower. Differences in eye size and shape may be discerned, however, and these together with shape of rostrum, dorsal carapace keel and maxilliped provide the most useful means of identification.

Key to the Species of *Nematoscelis*

1a. 2nd thoracic leg with apical tuft of spines arising from both dactylus and propodus. Ventro-lateral anterior spine on basal segment of antennal peduncle greatly projected. Adult size > 20 mm. Propodus of first thoracic leg with setae arranged in three rows.

2a. Petasma with proximal process reaching about to middle of serrated margin of terminal process. Propodus of first thoracic leg with 6 setae in dorsal (outer) row and 5 in middle row. ... *megalops*

2b. Proximal process reaches well beyond middle of serrated part of terminal process. Propodus of first leg with 5 setae in dorsal row and 4 in middle row ... *difficilis*

1b. 2nd thoracic leg with apical tuft of spines arising from dactylus only. Propodus of 1st thoracic leg with setae arranged in one or two rows. Adult size generally 10–20 mm.

3a. Propodus of 1st thoracic leg with setae arranged in two rows. Lateral process of petasma much longer than terminal and spine-shaped process.

4a. Lower lobe of eye much smaller than upper part. One long seta projects from dorsal surface of dactylus of 1st leg... *tenella*

4b. Lower lobe of eye as large as or larger than upper part. No seta on dorsal surface of dactylus of 1st leg... *gracilis*

3b. Propodus of 1st thoracic leg flattened and with setae in a single row. Lateral process of petasma much shorter than terminal and spine-shaped processes.

5a. Upper lobe of eye slightly narrower than lower. Propodus of 1st thoracic leg with seta-bearing margin barely convex and with 5–6 setae.

6a. Petasma with proximal process equal in length to or shorter than terminal, which is as long as spine-shaped process. Median lobe much higher than broad, rounded distally... *atlantica*

6b. Proximal and spine-shaped processes both longer than terminal. Median lobe of petasma very broad, with inner margin forming an acute distal angle with outer margin ... *lobata*

5b. Upper lobe of eye as wide as lower. Propodus of 1st thoracic leg with seta-bearing margin strongly convex and with 8–9 setae ... *microps*

Nematoscelis tenella G. O. Sars, 1883
Figs. 101, 122a

N. tenella G. O. Sars, 1883: 28–29; 1885: 133–134, pl.xxv, figs. 5, 7; Hansen, 1910: 110–112, pl. xv, fig. 4, a-m; 1912: 263–264, pl. x, fig. 3, a-c; Boden et al., 1955: 366–368, fig. 41; Gopalakrishnan (in press). *N. mantis* Chun, 1896: 165.

Eye: Upper lobe much larger than lower, 1½ times wider.

Peduncle of 2nd antenna: Ventro-lateral spine on coxal segment short, scarcely acute, barely extending over base of scale.

Rostrum: Obliquely triangular, reaching about to mid-point of eye. Horizontal in lateral view, same shape in both sexes.

Carapace: Gastric region elevated but with, at most, a short, low keel.

1st thoracic leg: One long seta on dorsal surface of dactylus. Propodus with two rows of setae.

Abdomen: Slender, contributing to elongate appearance of body.

Petasma: Spine-shaped and terminal processes both very small, spine-shaped being the longer, but, owing to differences in place of origin, the tips extend equi-distantly. Proximal process long, straight, tapering to a rounded end which bears saw-teeth on outer margin. Lateral process similar in shape to proximal, extending a little farther and with rounded rather than saw-like teeth on distal margin.

Length: 13–20 mm.
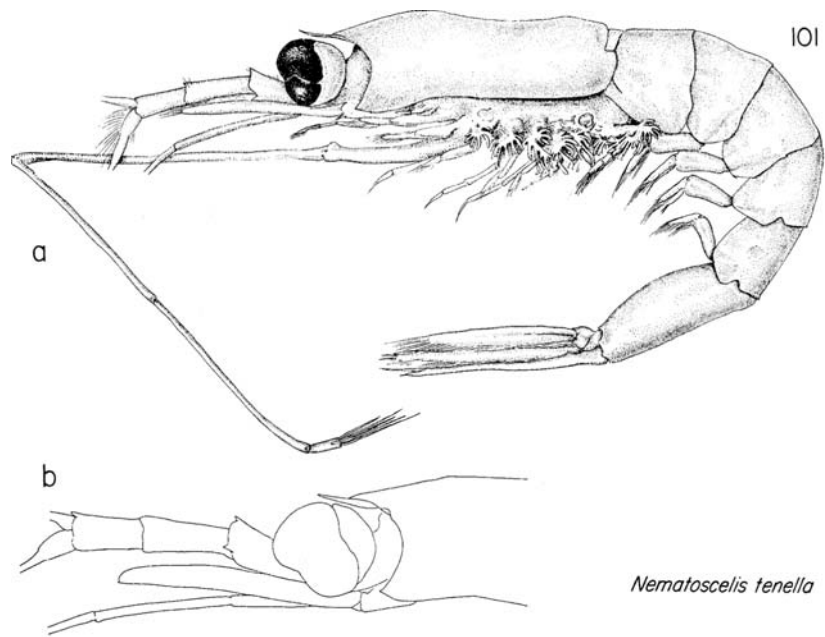
Figure 101. a) *Nematoscelis tenella*, b) peduncles of antennae and head region.
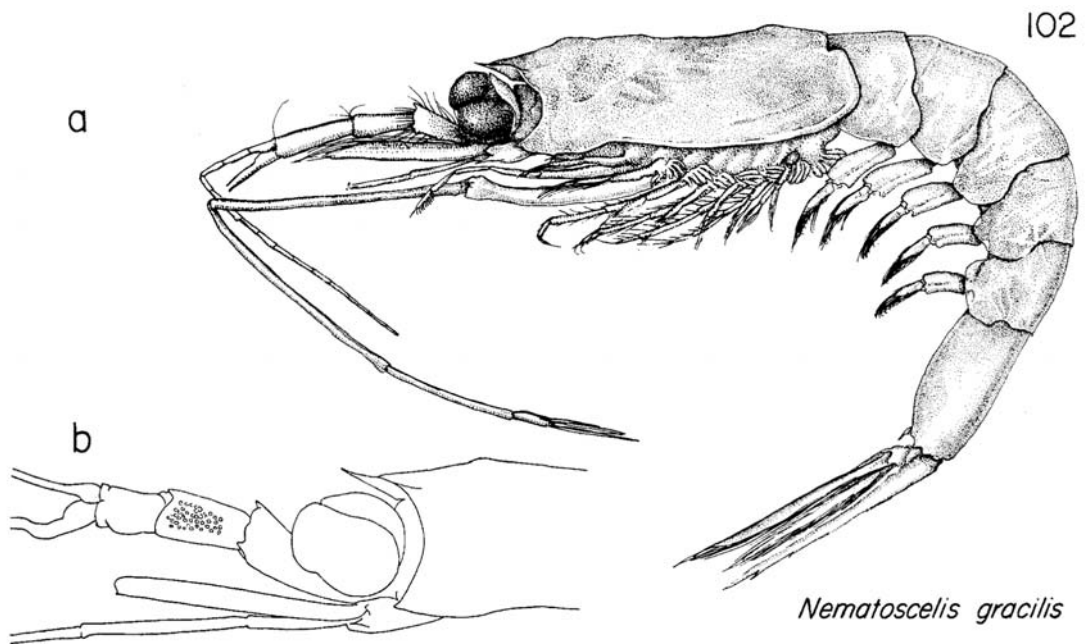
Figure 102. a) *Nematoscelis gracilis*, male, b) peduncles of antennae and head region showing shape of basal part of flagellum characteristic of female, and "glandular secretions" in 2nd peduncular segment characteristic of species.

Remarks: The relatively very large upper lobe of the eye is characteristic of *tenella*, within the genus. The body is distinctly slender. The small spine-shaped and terminal processes of the petasma resemble only *gracilis*.

Nematoscelis gracilis Hansen, 1910

Figs. 102, 122b

N. gracilis Hansen, 1910: 109–110, pl. xv, fig. 3, a-g; 1912: 261–263, pl. x, fig. 2a; Boden et al., 1955: 369–371, fig. 43; Gopalakrishnan (in press).

Eye: Upper lobe as broad as lower lobe, and appears to be bent somewhat forward.

Peduncle of 2nd antenna: Ventro-lateral spine on coxa acute, extending forward over base of scale, approximately to mid-point of eye.

Rostrum: Short, acute in both sexes, somewhat upturned and extending forward almost to mid-point of eye.

Carapace: With small ill-defined dorsal keel. No lateral denticles on carapace of adults.

1st thoracic leg: Dactylus straight, without seta on dorsal surface. Propodus slender with almost parallel margins, setae arranged in two rows, three setae on inner row and four on dorsal row.

Abdomen: No dorsal keels.

Petasma: Spine-shaped and terminal processes both very short. Proximal process not extending to end of median lobe in Gopalakrishnan's "Old Form", but extending well beyond that lobe in "New Form". Distal part of proximal process bears saw-teeth in "Old Form" but not in "New Form". Lateral process extends beyond end of proximal process in "Old Form" but not in "New Form". Further, Gopalakrishnan (in press) discusses petasma morphology in specimens believed to be intermediate between the two forms.

Length: 11.0–15.5 mm.

Remarks: The short, upturned rostrum is useful as a distinguishing character. The eye is a little smaller than in *microps*, and barely larger than in *atlantica*. The upper lobe bends somewhat forward in a characteristic way in this species.

Gopalakrishnan points out that, throughout the genus, the antennular peduncle of the male has the two distal segments thicker and shorter than in the female. The basal segment of the lower flagellum of the antennule is much thickened in the male. Only in *gracilis* does the proximal part of this flagellum bend downward, just beyond this enlarged segment (Fig. 102b). Globules, apparently of glandular origin are clearly visible within the 2nd segment of the antennular peduncle (Fig. 102b). The large size and opaque state of these globules are characteristic of *N. gracilis*.

Nematoscelis microps G. O. Sars, 1883

Figs. 103, 122c

N. microps G. O. Sars, 1883: 28; 1885: 131–133, pl. xxv, figs. 1-4; Hansen, 1910: 107–109, pl. xv, fig. 2, a-k; 1912: 259–261, pl. ix, fig. 4, a-d, pl. x, fig. 1, a-b; Ruud, 1936: 11–14, fig. 4; Boden et al., 1955: 368–369, fig. 42; Gopalakrishnan (in press). *N. rostrata* G. O. Sars, 1883: 29; 1885: 135–136, 169–170, pl. xv, figs. 8-10, pl. xxxi, figs. 23-29.

Eye: The two lobes are approximately equal in width and size, the upper lobe being sometimes wider but consistently lower.

Peduncle of 2nd antenna: Ventro-lateral spine on coxa acute, extending forward over base of scale, approximately to mid-point of eye.

Rostrum: Short or lacking in male, acute in female and reaching to anterior limit of eye. Lateral margins of frontal plate flare upward and outward, providing plate with elevated appearance in lateral view.

Carapace: Keel on dorsal anterior part of carapace well defined. Denticle present on lateral margin of carapace in male, lacking in female.

1st thoracic leg: Dactylus straight, evenly tapering, with single row of setae, no additional dorsal setae. Propodus with strongly convex inner margin bearing 8–9 setae in single row.

Abdomen: 4th and 5th segments with low, ill-defined keels.

Petasma: Spine-shaped and terminal processes reach equi-distantly. Proximal process thicker, longer than terminal, terminating bluntly. Lateral process stout, shorter than terminal, with rounded tip.

Length: 12–20 mm.

Remarks: The well-defined dorsal keel on the carapace, the sexually dimorphic rostrum, and the shape of the propodus of the first thoracic leg are particularly useful characters. The eye of this species is barely larger than in *gracilis* and *atlantica*.

The occurrence of enlarged abdominal photophores together with dorsal humps or callosities on abdominal segments has been observed in males of *microps*. The phenomenon has been discussed by Einarsson (1942), Taniguchi (1966), James (1973) and Gopalakrishnan (1973b, in press).

Nematoscelis atlantica Hansen, 1910

Figs. 104, 122d

N. atlantica Hansen, 1910: 106–110; Ruud, 1936: 11–14, figs. 3, 4, 16; Boden et al., 1955: 371–372, fig. 44; Gopalakrishnan (in press).

Eye: Symmetrical antero-posteriorly. Upper lobe slightly smaller and narrower than lower.

Peduncle of 2nd antenna: Ventro-lateral spine on coxa acute, extending almost to anterior limit of eye.

Rostrum: Long, slender, straight, acute in both sexes extending to, or beyond, anterior limit of eye.

Carapace: Dorsal keel low but distinct. A low, even, keel-like ridge extends anteriorly from the dorsal keel to rostral process. A lateral denticle is present at carapace margin in both sexes.

1st thoracic leg: Dactylus with outer margin strongly convex and inner setae-bearing margin concave. There is no dorsal seta. Propodus with a single row of 5 setae on inner margin.

Abdomen: Slender, without keels.

Petasma: Spine-shaped and terminal processes slender, of equal length, both barely longer than proximal process or about equal to it in length. Proximal process has filmy appearance, described by Hansen (1910) as "diaphanous". Lateral process equal in width to the proximal, but only about half as long. Median lobe narrow and extends well beyond processes.

Length: 10.5–15 mm.

Remarks: The eye, together with that of *lobata*, is the smallest in the genus. The body of this species is particularly slender, the long, straight, acute rostrum enhancing this feature. The keel on the frontal plate is low compared with that in male *lobata* (Fig. 104c) but is like that in female *lobata* (Fig. 104d).

<center>*Nematoscelis lobata* Hansen, 1916</center>

<center>Fig. 104 c, d</center>

N. lobata Hansen, 1916: 648–650, pl. lxxxiii, fig. 2, a-f; Gopalakrishnan (in press).

Eye: Small, as in *atlantica*. Upper lobe smaller and narrower than lower.

Peduncle of 2nd antenna: Ventro-lateral spine on coxa slender and acute in female, shorter and triangular in male.

Carapace: Frontal plate bears distinctly elevated keel, extending from small mid-dorsal carapace keel anteriorly onto rostrum. Lateral denticle present on carapace margin in male, but lacking in female.

1st thoracic leg: Dactylus with concave setae-bearing inner margin, as in *atlantica*. Propodus with single row of setae on inner margin.

Abdomen: Slender, without keels.

Petasma: Spine-shaped process distinctly longer and more slender than terminal. Proximal process broad at base, tapering to sub-acute tip. Lateral process sharply tapering distally, less than half as long as proximal. Median lobe extremely broad, nearly as broad as high, terminating in angle.

Length: 12–14.5 mm.
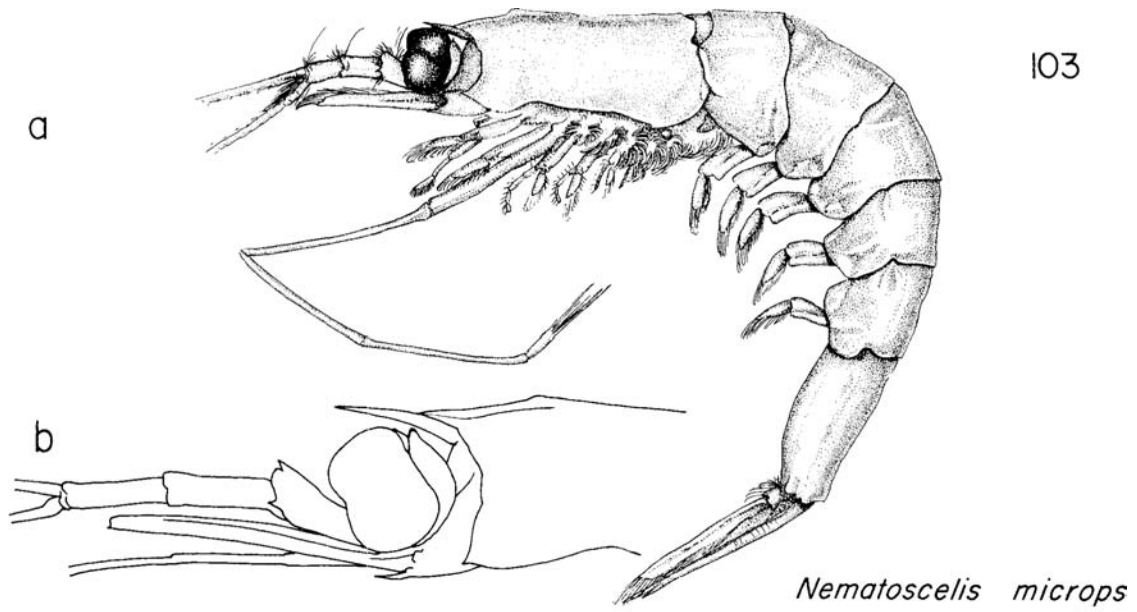
Figure 103. a) *Nematoscelis microps*, b) peduncles of antennae and head region.
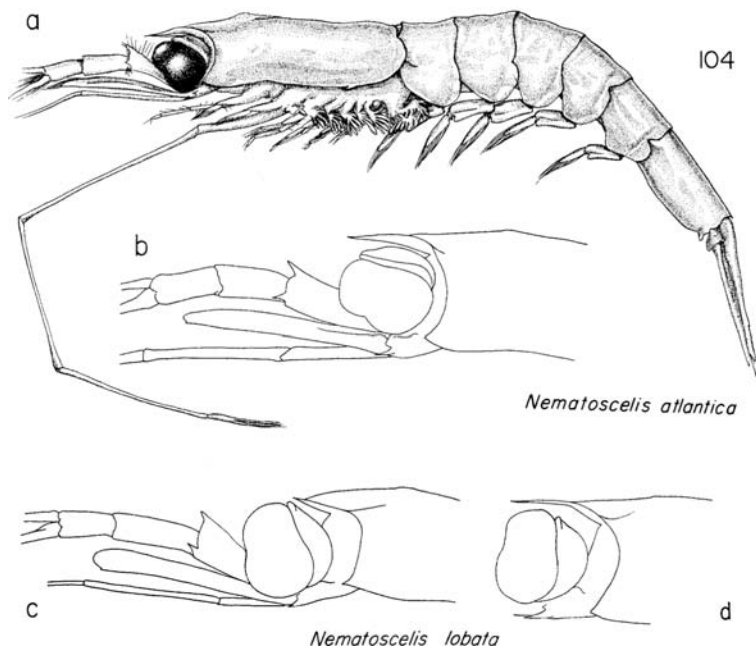
Figure 104. a) *Nematoscelis atlantica*, b) peduncles of antennae and head region, c) *N. lobata* male, d) *N. lobata* female.

Remarks: Gopalakrishnan pointed out that, on the basis of the structure of the first thoracic leg, *lobata* is most closely related to *atlantica*, rather than to *microps* as Hansen (1916) had indicated. The strongly keeled male frontal plate and the unique shape of the median lobe of the petasma are conspicuous specific characters.

<div align="center">Genus Nematobrachion Calman, 1905</div>

Generic diagnosis:

> Eyes large, bilobed, upper lobe broader than lower.

> 1st segment of peduncle of 1st antenna with an almost vertical lobe, scarcely overhanging 2nd segment.

> 3rd thoracic leg greatly elongated; merus bent downward proximally, then upward; dactylus elongated and armed at tip with five long serrated spines. 7th leg short, but with full number of segments. 8th leg rudimentary.

> Carapace with distinct transverse cervical groove.

> Terminal process of petasma short; upright, distally broad and receptacle-like. Proximal process long, slender, with proximal heel and strong curvature, of ca. 180°.

> Adults are 22–25 mm in length.

The three species provide contrasting degrees of spininess: *boöpis* is without antennular, carapace and abdominal spines, and is even without a rostrum; *flexipes* possesses rostrum, spines on the first two peduncular segments, at the lateral margin of carapace, and median spines on 3rd to 5th abdominal segments; *sexspinosus* possesses rostrum, antennular and carapace spines, three dorsal spine-like projections on each of 4th and 5th abdominal segments, and spine- or tooth-like ventral limits to abdominal pleura.

<div align="center">Key to the Species of Nematobrachion</div>

> 1a. Frontal plate produced as an acute rostrum. Abdomen with a median posterior spine only on 3rd segment or with spines only on 4th and 5th segments.

>> 2a. Abdomen with median posterior spine only on 3rd segment ... *flexipes*

>> 2b. Abdomen with median and medio-lateral spines on posterior margin of 4th and 5th segments ... *sexspinosus*

> 1b. Frontal plate short, obtuse, without rostral process. Abdomen without spines ... *boöpis*

<div align="center">Nematobrachion flexipes (Ortmann, 1893)
Figs. 105, 102f</div>

Stylocheiron flexipes Ortmann, 1893: 18, taf. 1, fig. vii. *Nematodactylus flexipes* Calman, 1896: 16. *Nematobrachion flexipes* Calman, 1905: 153–155; Hansen, 1911: 51; 1912: 269–272, pl. x, fig. 5, a-m; Banner, 1950: 15–18; Boden et al., 1955: 373–376, fig. 45.

Eye: Upper lobe barely wider than lower. Lobes of equal height, with constriction between them most evident on anterior side of eye.

Antennular peduncle: Elevated distal portion of 1st segment does not overhang 2nd segment, consists of short, almost vertical lobe appearing abruptly truncated (in lateral view), the flattened tip being usually in horizontal plane. Forward-directed spine on distal outer margin of 1st segment extends at least half length of 2nd segment.
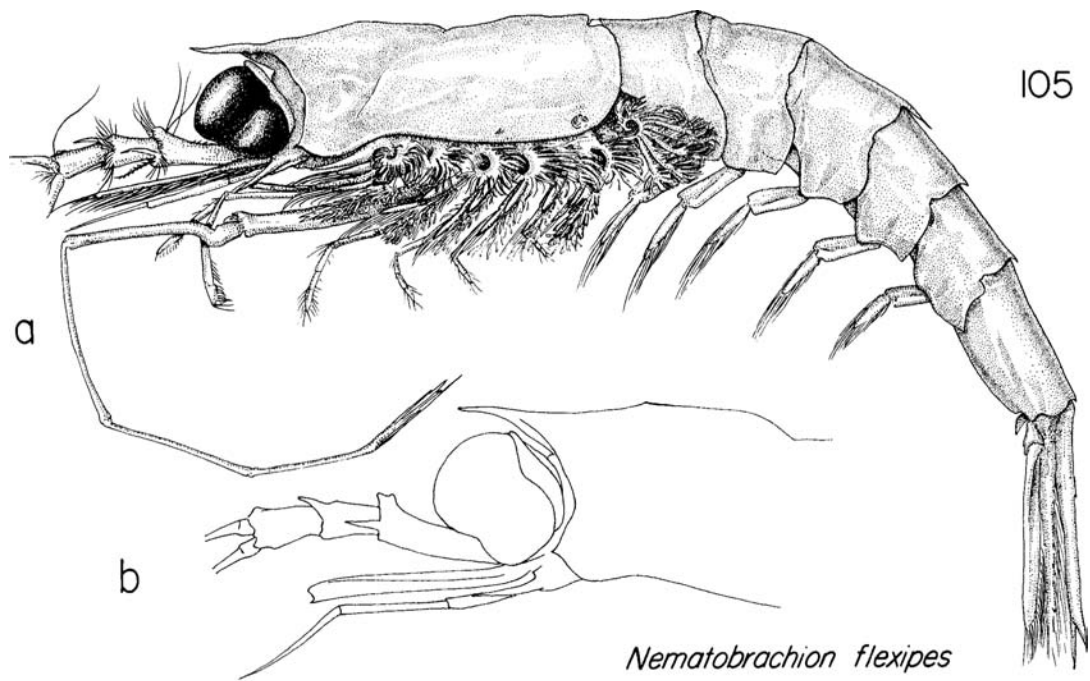
Figure 105. a) *Nematobrachion flexipes*, b) peduncles of antennae and head region.
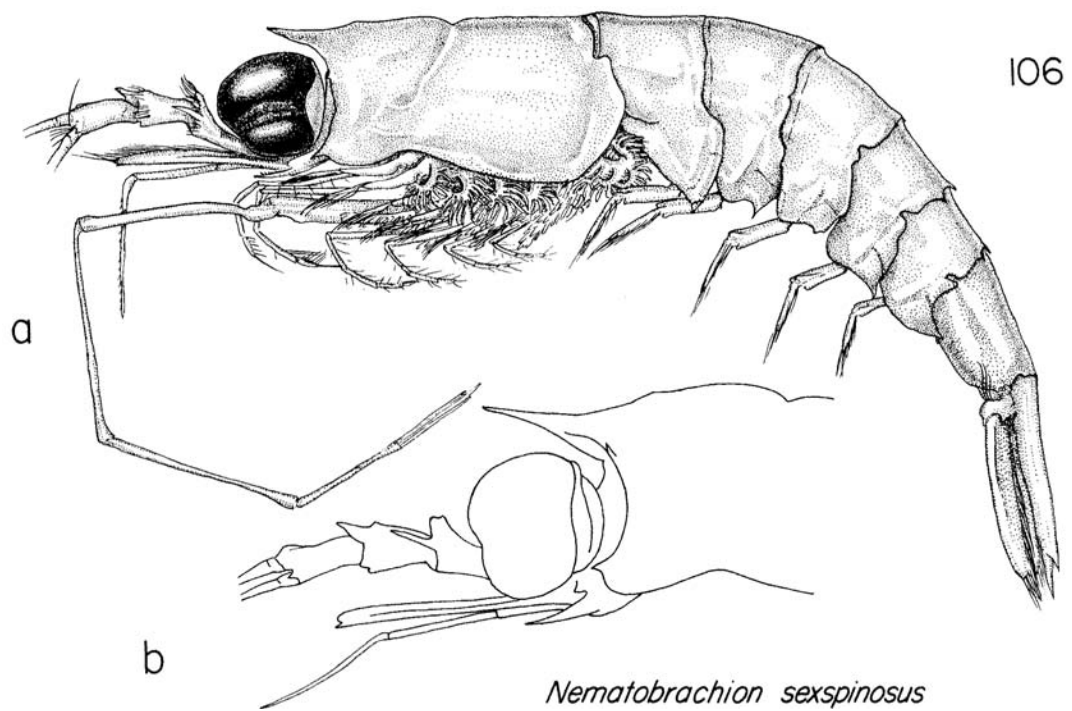
Figure 106. a) *Nematobrachion sexspinosus*, b) peduncles of antennae and head region.

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Proximal parts of 2nd and 3rd segments distinctly slender, as compared with adjacent distal parts of 1st and 2nd. 2nd segment bears strong forward-and slightly upward-directed tooth at outer dorsal angle. 3rd segment increases in height distally but without keel.

Rostrum: Extends to anterior limit of eye as a slender keeled extension of frontal plate. It projects slightly upward then directly forward.

Carapace: Frontal plate broadly triangular, bearing keel which has an essentially horizonal upper edge. The long low gastric keel bears a small elevation at its midpoint.

Abdomen: 1st and 2nd segments produced medially as short, rounded posterior projections. 3rd bears long median spine, 4th and 5th each bear shorter spine. 6th segment twice as long as deep, being deepest anteriorly.

Petasma: Terminal process broad, but strongly constricted medially; distal part irregularly ovoid with short, narrow distal projection and cleft. Proximal process longer, slender, curving 180°, terminating in somewhat broadened plate. Lateral process long, distally hooked. Additional process half as long as lateral, distal one-third sharply bent, terminating acutely.

Length: 20–23 mm.

Remarks: *N. flexipes* is easily separated from *sexspinosus* on the basis of the following: it has a tooth rather than a lappet on 2nd segment of antennular peduncle, the gastric area is most elevated anteriorly rather than posteriorly, the 3rd to 5th abdominal segments are each with one median spine, as compared with three spines on each of 4th and 5th segments in *sexspinosus:*

<div align="center">

Nematobrachion sexspinosus Hansen, 1911

Figs. 106, 122g

</div>

N. sexspinosus Hansen, 1911: 51; 1912: 272–273, pl. x, fig. 6a, pl. xi, fig. 1, a-i; Tattersall, 1927: 24: Boden et al., 1955: 376–377, fig. 46.

Eye: Upper lobe somewhat broader than lower. Height of eye greatest at posterior edge. Lobes equal in height.

Antennular peduncle: 1st segment with elevated distal lobe truncated at tip, (in lateral view), not overhanging 2nd segment. Forward-directed spine on distal outer margin of 1st segment extends to midpoint of 2nd segment. 2nd segment bears dorsal leaflet which overhangs 3rd segment; it is more elevated and spiniform in the male than in female. 3rd segment slightly elevated distally.

Rostrum: Extends to anterior limit of eye as slender upright keel, with base considerably higher than in *flexipes*. It is straight, angling barely upward above the eyes.

Carapace: Dorsal margin of frontal plate appears smoothly concave in lateral view. Carapace shorter in this species than in the two others in the genus. Domed gastric region highest just anterior to cervical groove, above which it rises abruptly. Dorsal prominence an indistinct nub, situated anterior to highest elevation of gastric keel. There is a postero-lateral carapace denticle.
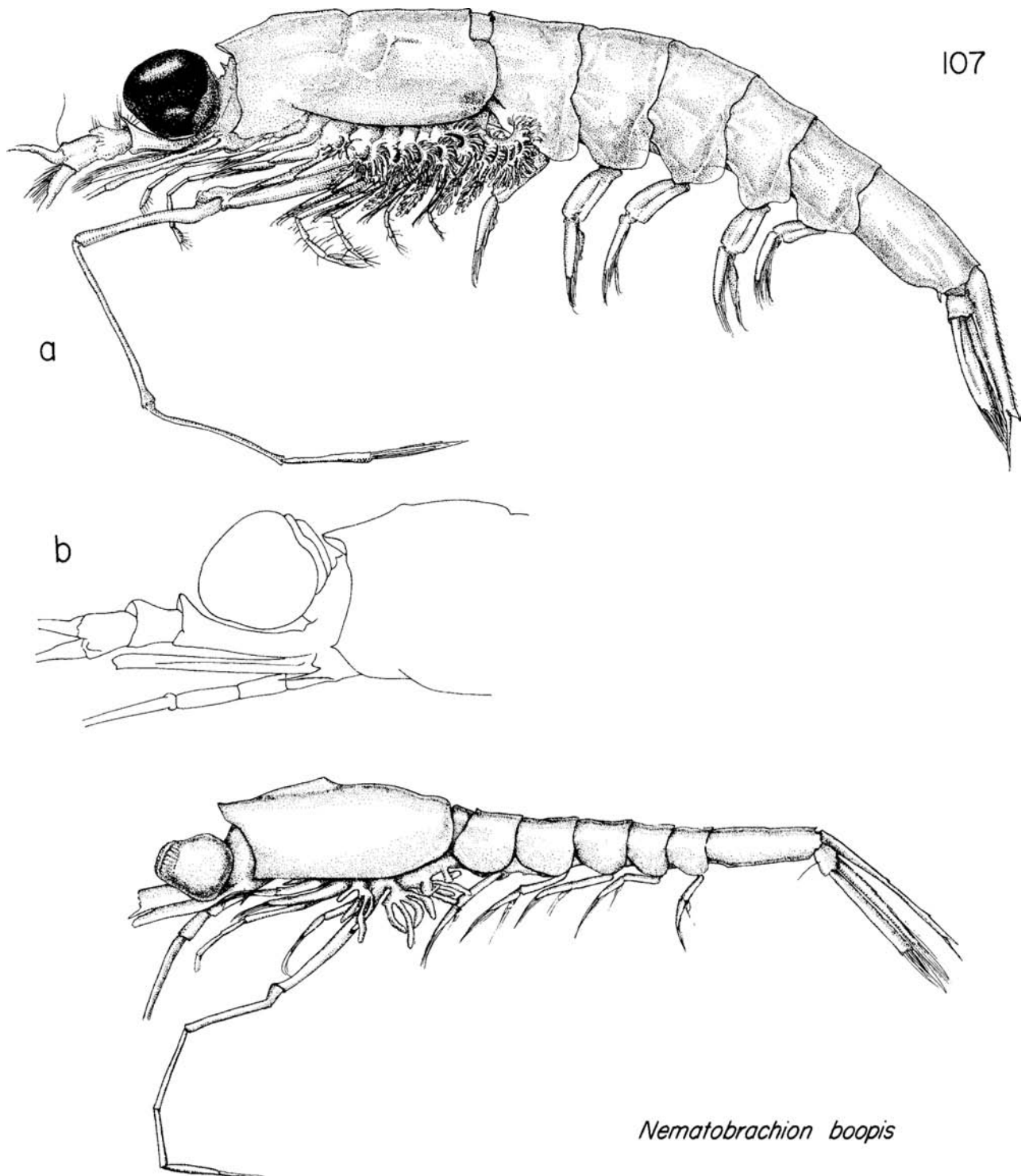
Nematobrachion boopis

Figure 107. a) *Nematobrachion boöpis*, b) peduncles of antennae and head region, c) 7 mm juvenile.

Abdomen: 1st and 2nd segments barely extended posteriorly, not acuminate, 3rd segment not extended. 4th and 5th each with short, slender median spine flanked by pair of shorter spines on sub-dorsal posterior margin. 6th segment with short median spine. Pleura of abdominal somites end postero-laterally at acute angles. 6th segment short, 1.7 times longer than deep.

Petasma: Terminal process short, stocky, slightly bent just beyond base, terminating in broad notch. Proximal process slender, extending through semi-circle, terminating at point beyond tip of terminal process. Lateral process slender, distally hooked. Additional process half as long as lateral, the distal half being broadly hooked. Length: 20–25 mm.

Remarks: This species is stockier in appearance than *flexipes* or *boöpis, e.g.*, the short carapace and 6th abdominal segment. See *N. flexipes* "Remarks" for comparison with *sexspinosus*.

Nematobrachion boöpis (Calman, 1905)

Figs. 107, 122h

Nematodactylus boöpis Calman, 1896: 17. *Nematobrachion boöpis* Calman, 1905: 153–154, pl. xxvi; Hansen, 1912: 267–269, pl. x, fig. 5, a-m; Illig, 1930: 533–534, figs. 210-211; Boden et al., 1955: 377–379, fig. 47.

Eye: Upper lobe 1½ to 2 times as wide as lower. Region between two lobes scarcely constricted, occupied by broad lightly pigmented band.

Antennular peduncle: Lobe on 1st segment upright, narrow (in lateral view) distally rounded. Dorsal, distal portions of 2nd and 3rd segments slightly elevated but without teeth or keels.

Carapace: Without rostrum. Frontal plate broadly triangular, extending to posterior limit of eye. Gastric region somewhat elevated anterior to cervical groove but not domed, and with a short, low keel anteriorly. Without lateral denticles, but with notch-like discontinuity in lateral margin between head and thorax.

Abdomen: Without median spines. 6th segment twice as long as deep, maximum depth being toward posterior part of segment.

Petasma: Terminal process broad at base then narrowing abruptly, with distal two-thirds broadened and tip with depression overhung by low acute projection. Proximal process longer, arcs in a semi-circle. Lateral process almost straight, acutely hooked. Additional process shorter, broader at base, distally acute and hooked. Length: 20–25 mm.

Remarks: The extremely broad upper lobe of the eye, and the absence of a rostrum are conspicuous characters.

Genus *Stylocheiron* G. O. Sars, 1883, 1885

Generic diagnosis:

Eyes typically elongate and bilobed, upper lobe being distinctly narrower than lower (except in *longicorne, elongatum* and *maximum*, where upper lobe may be equal in width to lower). In smaller species, 6–12mm in length, upper lobe bears enlarged crystalline cones distally.

Peduncle of first antenna with long and slender 2nd and 3rd segments in female, shorter and thicker in male. No peduncular lobes, lappets or spines that are species-specific in structure (except in *indicus*). Upper flagellum shorter than lower. Peduncle of endopod (flagellum bearing) of 2nd antenna extremely elongate, with penultimate segment reaching beyond end of scale (squama).

First and second thoracic legs short and slender. Leg three extremely elongate and bears short ischial, meral and carpal segments; strong spiniform bristles of broadened propodal segment, together with spines or spine-like process of terminal segment form a chela or chela-like grasping structure. Remaining thoracic legs diminish in length posteriorly, 8th being rudimentary.

Carapace without lateral denticles.

Processes of petasma, except for spine-shaped process, at most slightly curved. Terminal and proximal processes often blunted, blade-like and difficult to use for taxonomic purposes.

Abdomen bears single photophore, situated on mid-ventral line of 1st segment.

Nine of the ten species recognized in this genus fall into two groups. The "Stylocheiron longicorne group" includes six species, characterized by the presence of a "false chela" on the 3rd thoracic endopod, formed of bristles on propodal and dactyl segments: *S. longicorne* (with 2 described forms and one newly described here), *S. affine* (with 5 described forms), *S. elongatum, S. suhmii, S. microphthalma, S. insulare* and *S. indicus*. The "Stylocheiron maximum group" includes three species characterized by a true chela on the 3rd thoracic leg: *S. maximum, S. abbreviatum* and *S. robustum. S. carinatum* differs from both groups in structure of the 3rd leg, the setae and bristles of the grasping organ being relatively less specialized. *S. armatum* Colosi, 1917, is of uncertain validity, being similar to or identical with *S. carinatum.*

All species of the genus, with the possible exception of *S. indicus*, occur in Indo-Australian waters. Immature specimens from the Sulu Sea and east of Halmahera, here tentatively assigned to *S. indicus*, may prove to be identical with that species.

Key to the Species of *Stylocheiron*

1a. Penultimate segment of elongated 3rd thoracic leg with setae simple, lateral rather than terminal, nearly equal in length, directed latero-distally, forming, together with similar simply-curving setae on dactylus, a grasping organ (false chela). Gastric region carinated but scarcely elevated. Thorax slender ... *carinatum*

1b. Penultimate segment of elongated 3rd thoracic leg with setae finely serrate on grasping margins, bristle-like, distally-curved, unequal in length, and extending parallel with axis of limb so as to form, together with similar setae on dactylus, a false chela. Gastric region domed. Thorax short, appearing somewhat deeper than in 1a.

2a. Upper lobe of eye distinctly narrower than lower.

3a. 6th abdominal segment with ventral margin angularly upturning near posterior limit. Upper lobe of eye approximately 1/4 width of lower lobe.

    4a. Upper lobe of eye with three crystalline cones in distal transverse row ... *suhmii*

    4b. Upper lobe of eye with four, rarely five, crystalline cones in distal transverse row ... *insulare*

3b. 6th abdominal segment smoothly narrowing (in lateral view) posteriorly.

    5a. Upper lobe of eye with 4 to 8 crystalline cones in distal transverse row ... *affine*

    5b. Upper lobe of eye with two crystalline cones in distal transverse row ... *microphthalma*

    5c. Upper lobe of eye with 14 to 16 crystalline cones in distal transverse row ... *indicus*

2b. Upper lobe of eye as wide as, or scarcely narrower than, lower lobe.

    6a. 6th abdominal segment more than 4 times as long as deep. Eye consistently with upper lobe as wide as lower lobe ... *elongatum*

    6b. 6th abdominal segment 1.63 to 2.4 times as long as deep ... *longicorne* (eye with upper lobe as wide as lower in "Long Form", but upper lobe narrower in "Short Form" and "North Indian Ocean Form")

1c. Penultimate segment of elongated 3rd thoracic leg with a long, strong distally-curving spine which serves as an immovable finger, opposing the distally-serrate dactyl segment so as to form a true chela. Gastric region domed.

    7a. Upper lobe of eye nearly equal in width to lower lobe. 6th abdominal segment more than 2.3 times longer than deep ... *maximum*

    7b. Upper lobe of eye distinctly narrower than lower lobe. 6th abdominal segment less than 2.1 times longer than deep.

        8a. 4th and 5th abdominal segments bear low mid-dorsal keels ... *abbreviatum*

        8b. 4th and 5th abdominal segments without mid-dorsal keels ... *robustum*

Stylocheiron carinatum G. O. Sars, 1883
Figs. 108, 123a

S. carinatum G. O. Sars, 1883: 31; 1885: 137–142, pl. xxvi; Hansen, 1910: 113–115, pl. xvi, fig. 1. a-h: 1912: 274–276, pl. xi, fig. 2, a-b; Boden et al., 1955: 380–381, fig. 48.

Eye: Lower lobe large, nearly spherical. Upper lobe short and narrow, with lateral margins of pigmented part appearing nearly parallel. Crystalline cones at limit of upper lobe somewhat, though not conspicuously, enlarged, with 6–8 in transverse row.

Rostrum: Straight. acute, extending beyond anterior limit of eye in both sexes.

Carapace: Gastric region a low dome or scarcely elevated, bearing a dorsal keel or carina.

Abdomen: Body appears generally slender, 6th abdominal segment long, approximately 2.2 times as long as deep.

Third thoracic leg: Endopod elongated, with penultimate segment bearing a short seta on upper, anterior edge and three longer setae on lower or posterior edge. These three setae are simple, lateral rather than terminal, nearly equal in length, directed latero-distally so as to form, together with similar simply-curving setae on the dactylus, a false chela or grasping organ.
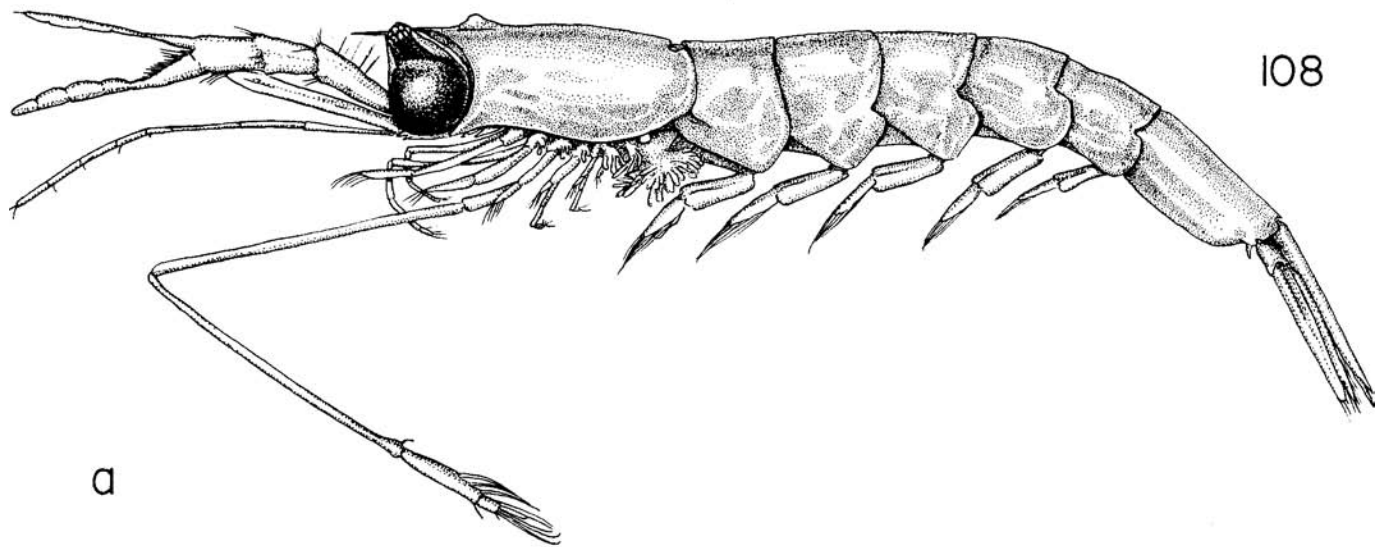
Stylocheiron carinatum
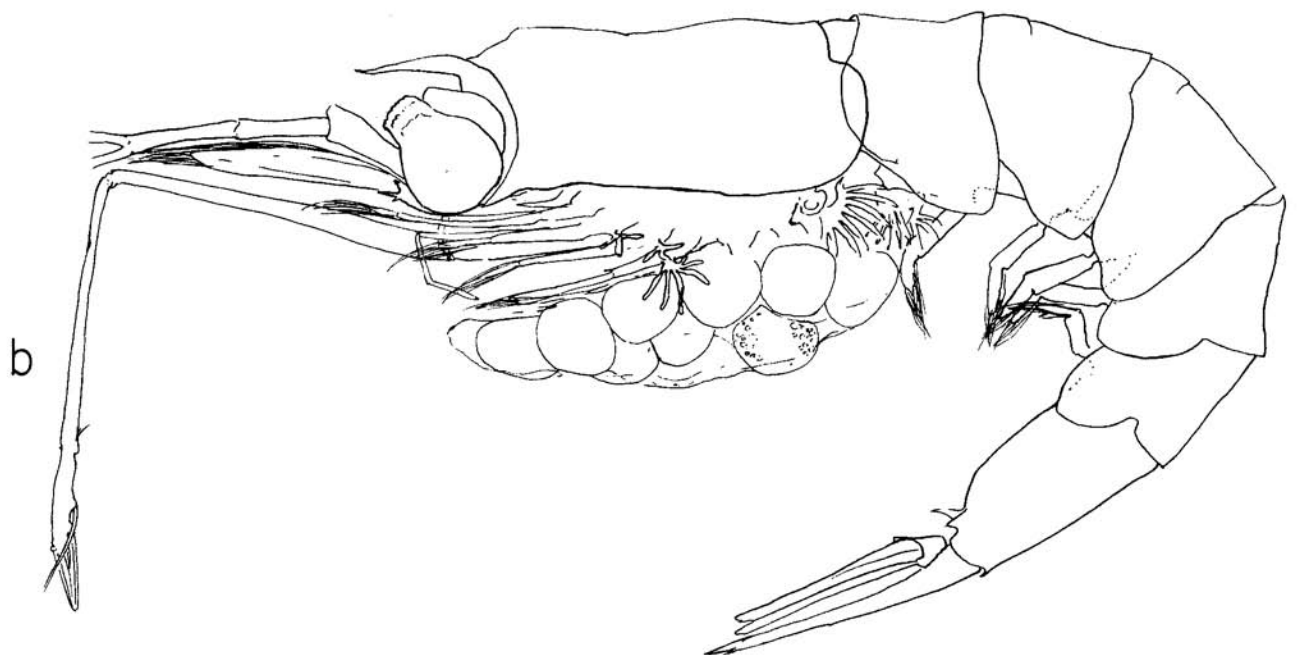
Figure 108. *Stylocheiron carinatum*, a) male, b) female showing eggs.

Petasma: Terminal process flat and broad with truncated, crenulated or finely serrated end and with two spine-like projections on inner edge. Proximal process even broader, particularly at its mid-point, and longer than terminal; the distal margin bears minute crenulations. Lateral process a little shorter and much more slender than proximal. It terminates in a curved tooth and bears a smaller outer tooth just before its end.

Length: 6–12 mm.

Remarks: The slender body with the thorax appearing nearly cylindrical and the long 6th abdominal segment, together with the carinated gastric region, the long straight rostrum, and particularly the eye shape (upper lobe short, narrow and somewhat cylindrical), provide distinctive characteristics.

Stylocheiron suhmii G. O. Sars, 1883

Figs. 109, 123b

S. suhmii G. O. Sars, 1883: 31–42; 1885: 142–144, pl. xxvii, figs. 1-4; Hansen, 1912: 271–278, pl. xi, fig. 3, a-b; Boden et al., 1955: 383–385, fig. 50; Brinton, 1962a: table 12; *S. mastigophorum* Chun, 1896: 144, pl. ix (*partim*).

Eye: Narrow, particularly upper lobe which bears three crystalline cones in transverse row. Length of eye 0.57–0.61 mm. Lower lobe 3.9–4.3 times width of upper lobe measured near its distal limit.

Rostrum: Slender, acute in females, extending to anterior limit of eyes. Frontal plate terminates in short, acutely triangular plate in males.

Carapace: Gastric region domed, with small mid-dorsal nub, scarcely keel-like.

Abdomen: 6th segment 1.66–1.69 times as long as maximum depth; ventrally, its margin (in lateral view) angles sharply upward at a point somewhat forward of posterior limit of segment, so that terminal depth of segment is distinctly less than that at point of maximum depth.

Third thoracic leg: Third endopodite with "false chela" typical of form found throughout "S. longicorne group": distal spines and bristles on penultimate segment curve medially so as to oppose similar spines extending from dactylus.

Petasma: Terminal process barely expanded distally with smooth margin. Proximal process about as long as terminal, and slightly concave along outer sub-distal margin. Lateral process straight, simple and shorter and more slender than terminal and proximal.

Length: 6–7 mm.

Remarks: The adult is distinguished by the three enlarged crystalline cones in transverse rows of the upper lobe of the eye, and by the angular irregularity in the shape of the ventral margin of the 6th abdominal segment (cf. *S. insulare*).
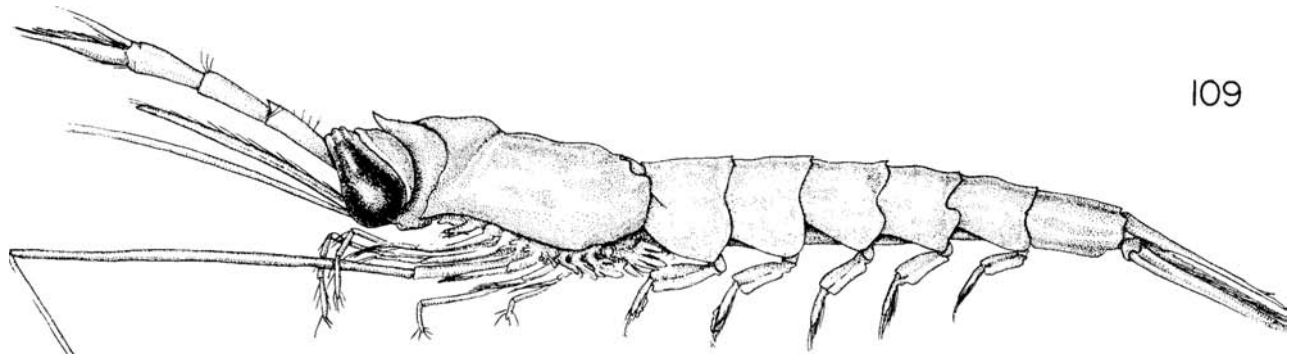
Figure 109. *Stylocheiron suhmii*, male.
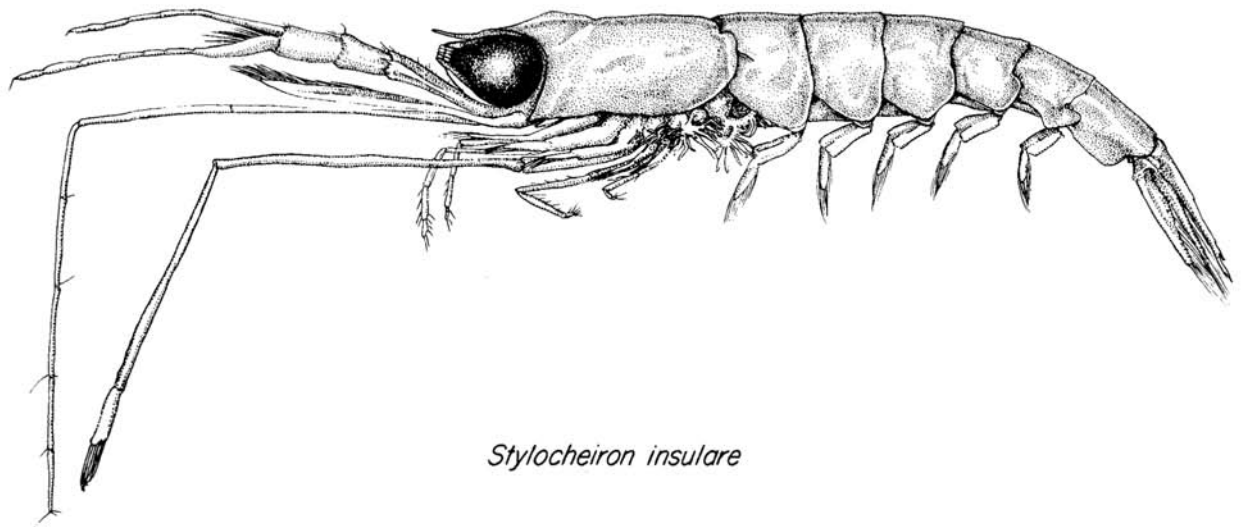
Figure 110. *Stylocheiron insulare*, male.

Stylocheiron insulare Hansen, 1910

Figs. 110, 123c

S. insulare Hansen, 1910: 115–117, pl. xvi, fig. 2, a-i; Brinton, 1962a: table 12, fig. 92k.

Eye: Lower lobe spherical. Upper lobe short, narrow, bearing 4–5 enlarged crystalline cones in transverse row. Length of eye 0.70–0.81 mm. Lower lobe 3.78–4.16 times wider than the upper lobe measured near its distal limit.

Rostrum: Slender, acute in females. Frontal plate short, acutely triangular in males.

Carapace: Gastric region domed with small dorsal keel-like elevation.

Abdomen: 6th segment appears short, 1.25–1.39 times as long as deep. Anterior three-fourths of ventral margin of 6th segment straight, parallel with dorsal margin; posterior one-fourth of ventral margin angles sharply upward then posteriorly, forming ventral-subterminal indentation, more pronounced than in *S. suhmii*.

Third thoracic leg: With the "false chela" characteristic of the "S. longicorne group", formed of spiniform bristles from the propodal and dactyl segments.

Petasma: Terminal process a broad blade, 3.5–4 times as long as broad, narrowing and then abruptly truncated distally. Proximal process shaped like terminal but somewhat broadened distally. terminating more roundly than squarely. Lateral process a bit shorter than terminal and proximal processes and half as broad.

Length: 6.5–8.2 mm.

Remarks: The eye is the stubbiest in the "S. longicorne group", with the upper lobe short and the lower lobe relatively very broad. The acuteness of the ventral angle on the lower margin of the 6th abdominal segment is characteristic.

Stylocheiron affine Hansen, 1910

Figs. 111, 123 d-f

S. affine Hansen. 1910: 118–120, pl. xvi, fig. 4, a-d, 1912: 278–279; Boden et al., 1955: 382–383, fig. 49; Brinton. 1962a: 178–190, figs. 92, a-i, 93b.

Eye: Oblong, with upper lobe about half width of lower lobe. Length of eye varies from small (0.62 mm in length in "Indo-Australian Form") to large (1.25 mm in length in "Central Form") in specimens of the same body length, 7.0–7.3 mm. There are as few as 4 or as many as 8 enlarged crystalline cones in a transverse row at distal limit of upper lobe of eye.

Rostrum: Long and slender in female reaching to or beyond anterior limit of eye. Short and acute in male, not reaching to anterior limit of eye.

Carapace: Gastric region domed, with poorly-defined mid-dorsal keel.
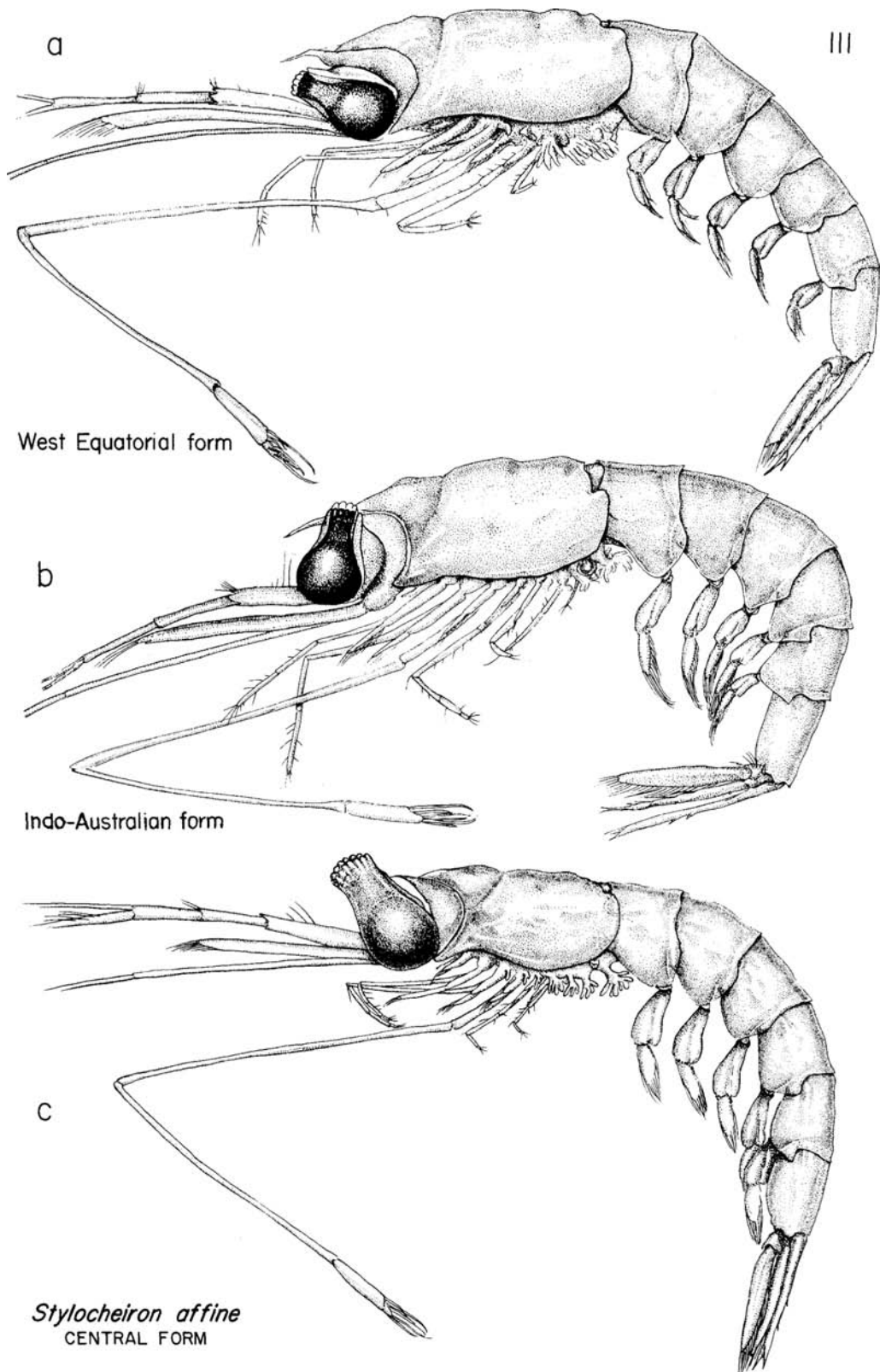
Figure 111. *Stylocheiron affine*, a) West Equatorial Form, b) Indo-Australian Form, c) Central Form.

Abdomen: 6th segment of variable length, with length-to-depth ratio as low as 1.4 in "Central Form", and as high as 1.93 in "Western Equatorial Form" and 2.44 in "California Current Form". The ventral margin of this segment is smoothly curved (cf. *S. insulare* and *S. suhmii*).

Third thoracic leg: Greatly elongated, with false chela formed of distal bristles on propodus and dactylus. This grasping organ is of the same structure found in other species of the "S. longicorne group".

Petasma: Terminal process generally of same width throughout, distally blunted and serrated, with inner margin concave near mid-point, and outer sub-distal surface somewhat hollowed, forming a groove-like identation against which tip of proximal process appears to rest. Proximal process nearly as long as terminal, with distal part broadened and terminal margin serrated. Lateral process, more slender and a little shorter than terminal and proximal, and distally curving outward and terminating sub-acutely. There appear to be no differences among the petasmas of different geographical forms (Figs. 123 d-f).

Length: 5.8–8.5 mm.

Remarks: For the Pacific, five geographical forms, or races, were recognized (Brinton, 1962a). They were considered ecophenotypes because of the concurrence of morphologically intermediate specimens with geographically intermediate habitats. Three of these forms, "Western Equatorial Form", "Central Form," and "Indo-Australian Form" occur in the Indo-Australian area.

S. affine in the Arabian Sea and Bay of Bengal is similar to, if not identical with, the "Indo-Australian Form." Its measurements fall within the range delimiting that form.

Specimens I have seen of *S. affine* from the South Atlantic appear similar to the "Central Form", while those from the northeastern Atlantic measured by Baker (1970) were generally of the "Central" type but with a somewhat broader range of values for the two diagnostic ratios (width of lower lobe of eye/width of upper lobe, and length of 6th abdominal segment/depth of 6th segment, Table 5) extending somewhat into the ranges of those values designated "West Equatorial Form" by Brinton. The form or forms of this species in the Atlantic, appear to be like or close to the "Central Form" of the Indian and Pacific Oceans.

The present figures of those forms of *S. affine* which occur in waters of the Archipelago are supplemented with diagnostic measurements of eye and 6th abdominal segment, modified from Brinton (1962a, table 12) to include all seven species of the "S. longicorne group" including also, five geographical forms of *S. affine* and three of *S. longicorne* (Table 5).

Stylocheiron microphthalma Hansen, 1910
Figs. 112, 123g

S. microphthalma Hansen, 1910: 117–118, pl. xvi, fig. 3, a-d; Boden et al., 1955: 385–386, fig. 51.

Eye: Small and narrow, particularly upper lobe which has only two enlarged crystalline cones in transverse row, four altogether. Lower lobe is 2.5–3.0 times width of upper lobe.

Rostrum: Produced as an acute process in female but a triangular plate in male.
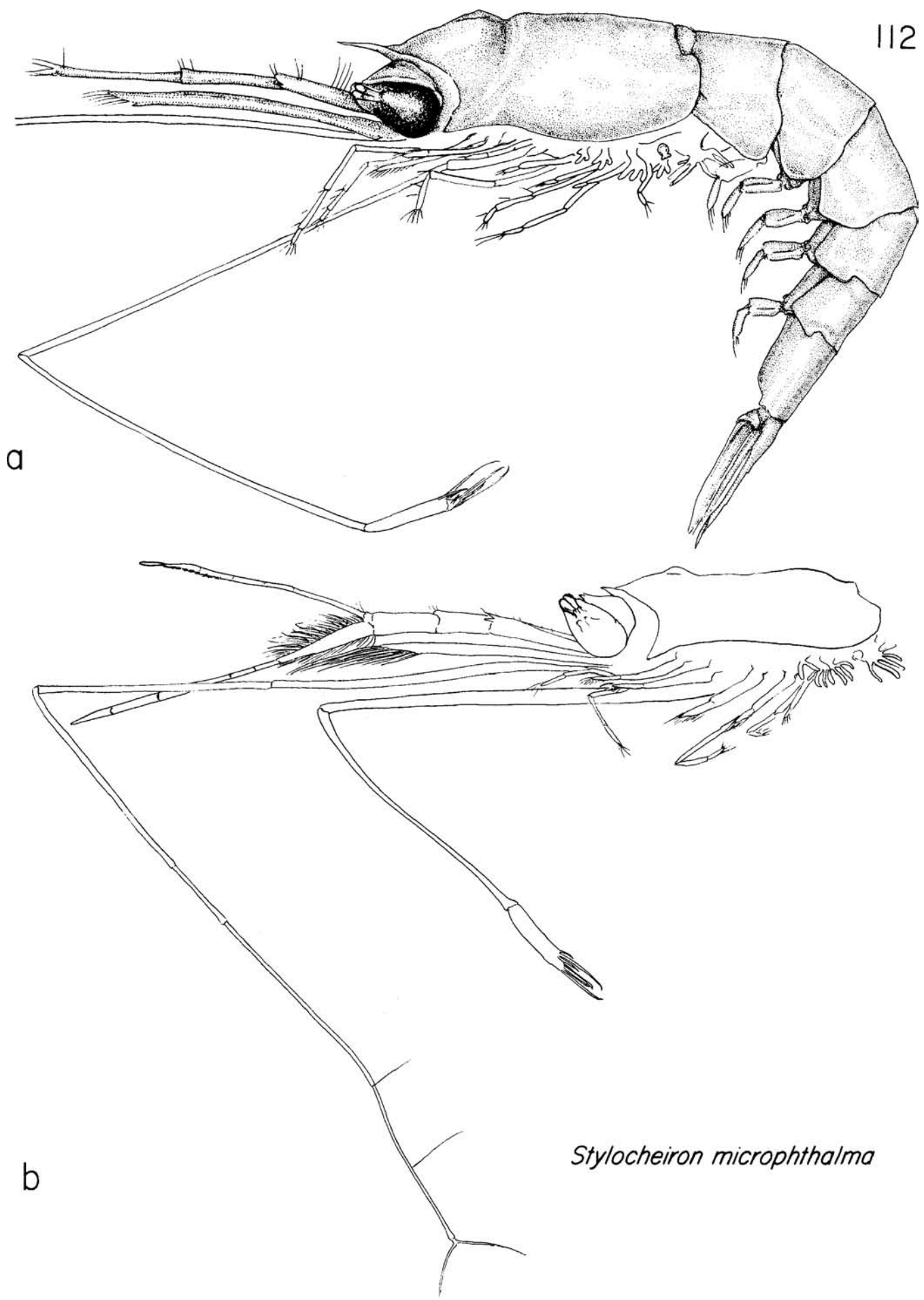
Figure 112. *Stylocheiron microphthalma*, a) female, b) male, anterior parts.

Carapace: Gastric region domed with mid-dorsal elevation or ill-defined keel.

Abdomen: 6th segment rather short, 1.46–1.60 times as long as maximum depth. Ventral margin curves distinctly upward posteriorly, but not as abruptly as in *insulare* and *suhmii*.

Third thoracic leg: With the "false chela" characteristic of the "S. longicorne group," formed of spiniform bristles from propodal and dactyl segments.

Petasma: Terminal process blade-like, truncated terminally with outer distal angle acute, and inner obtuse. Proximal process terminates in a sub-acute tip directed laterally and outward. Lateral process less broad than terminal and proximal, and terminates bluntly.

Length: 6–7 mm.

Remarks: The slender eye of the adult, terminating always in four enlarged crystalline cones (two in transverse row) is characteristic.

Stylocheiron indicus Silas and Mathew, 1967

Figs. 113, 123h

S. indicus Silas and Mathew, 1967: 169–172, fig. 1.

Eye: Lower lobe oblate, somewhat higher than wide, 1.46–1.86 times wider than upper lobe. Upper lobe a little shorter than wide, without any conspicuously enlarged crystalline cones, but with 14–16 facets in distal transverse row.

Antennae: First segment of peduncle of 1st antenna with an acute spine mid-ventrally at its distal end (noted by Silas and Mathew; not seen on our juvenile specimens). Terminal segment of peduncle of 2nd antenna with two spines at outer distal margin (called attention to by Silas and Mathew: now found to be general to "S. longicorne group," see remarks under *S. longicorne*. below).

Rostrum: Sub-acute or rounded, not spiniform, in both sexes, reaching about to mid-point of eye. Barely longer in female than male, and of same shape.

Carapace: Gastric region a low dome, with a low mid-dorsal keel which is relatively longer than in other species of the "S. longicorne group".

Abdomen: 6th abdominal segment long, 2.01–2.53 times as long as deep; ventral margin smoothly rounded throughout length.

Third thoracic leg: With "false chela" formed of bristles from propodal and dactyl segments. Propodus conspicuously expanded (up to point of origin of bristles), with margins straight, progressively diverging distally. All five bristles (spines) on outer and distal margins of dactylus curve inward; the single spine on inner margin of irregular curvature and directed inward, towards propodal bristles, at an oblique angle. The bristles of this leg appear shorter and somewhat more "tangled" than in other species of the "S. longicorne group."
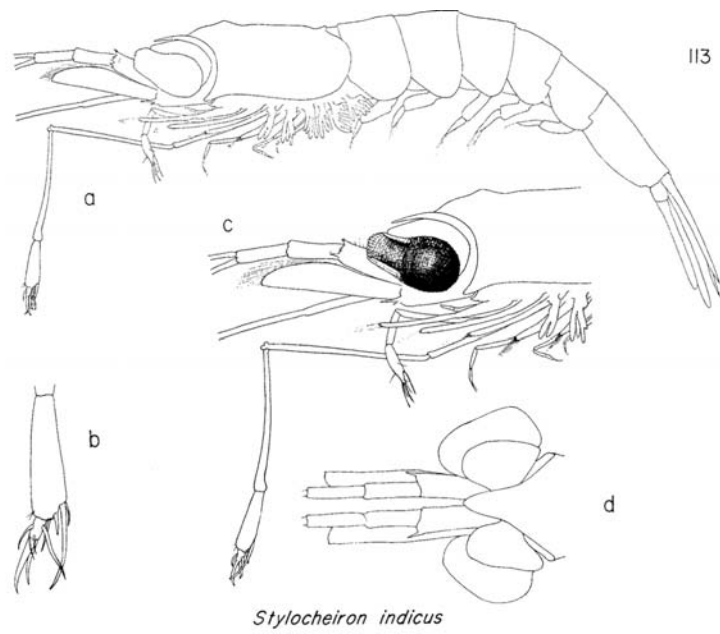
Figure 113. a) *Stylocheiron indicus*, 7 mm juvenile specimen from Sulu Sea, b) false chaela of 3rd thoracic leg, c) anterior parts, lateral, d) anterior parts, dorsal.
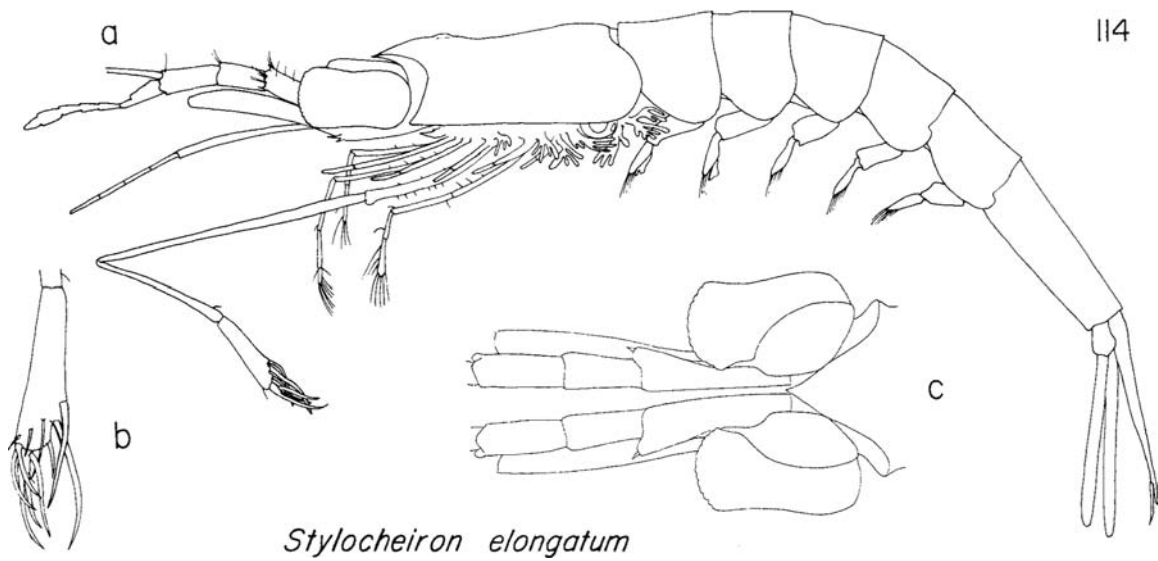
Figure 114. a) *Stylocheiron elongatum*, male, b) false chaela of 3rd thoracic leg, c) anterior parts, dorsal.

Petasma: Inner lobe with rudimentary spine on small lobe along its inner margin. Terminal process uniformly broad, distally curved as a hook, narrowing to an acute tip. Proximal process slightly shorter than terminal, tapering to an acute tip with its distal one-third strongly bent outward Lateral process minute, pointed, hardly one-sixth length of terminal process.

Length: 8.25–13.75 mm.

Remarks: Adult measurements and proportions and the description of the petasma are from Silas and Mathew (1967). The present specimens are all immature, the largest having a body length of 7.0 mm. This species falls in the "S. longicorne group" in view of the typical structure of the false chela. It does, however, differ from other species of the group in the following respects: 1) upper lobe of eye without conspicuously enlarged crystalline cones, 2) mid-ventral distal spine on first segment of antennular peduncle, presumably an adult character, noted by Silas and Mathew, 3) tip of rostral process bluntly rounded and nearly of same length in both sexes.

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Stylocheiron elongatum G. O. Sars, 1883

Figs. 114, 123i

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S. elongatum G. O. Sars, 1883: 32–33; 1885: 146–147, p1. xxvii, figs. 6-10; Boden et al., 1955: 386–388, fig. 52; Brinton. 1962a: table 12.

Eye: High, cylindrical in appearance, with upper and lower lobes nearly equal in width. Overall height of eye 1.40–1.67 mm; ratio of width-of-upper-lobe to width-of-lower-lobe ranges from 0.96–1.02. At distal limit of upper lobe there are 13–16 crystalline cones in transverse row.

Rostrum: Lacking in both sexes. Frontal plate produced as an acute triagle extending into a spiniform process.

Carapace: Gastric area elevated as low dome with low median keel.

Abdomen: 6th segment much elongated, ratio of length to depth is 4.18 to 4.19.

Third thoracic leg: Greatly elongated, with false chela formed of distal bristles on propodus and dactylus. This grasping organ is of same structure found in other species of the "S. longicorne group".

Petasma: Terminal and proximal processes are slender, of similar length, and tapering to acute tips. Tip of proximal process curves inward. Lateral process minute.

Length: 11.5–18 mm.

Remarks: This species is characterized by the long slender body with greatly elongate 6th abdominal segment, together with the similar proportions of the upper and lower lobes of the eye. *S. elongatum* shares these two characteristics with young specimens of *Nematobrachion flexipes* and *N. sexspinosus* which, however, may be distinguished by the presence of lateral carapace denticles and a rostral process.

Stylocheiron longicorne G. O. Sars, 1883
Figs. 115, 124 a-c

S. longicorne G.O. Sars, 1883: 32; 1885: 144–145, p1. xxvii, fig. 5; Hansen, 1910: 120–121, p1. xvi, fig 5, a-b; 1912: 279–280, p1. xi, fig. 4, a-b; Banner, 1950: 37–38, p1. iv, fig. 25a; Boden et al., 1955: 388–389, fig. 53; Brinton, 1962a: 190–193, figs. 93b, 98. *S. mastigophorum* Chun, 1887: 30 (*partim*).

Eye: Width of upper lobe approaches width of lower lobe and sometimes exceeds it. Ratio of width-of-lower-lobe/width-of-upper-lobe ranges from 0.86 to 1.44. There are 7–19 enlarged crystalline cones in a transverse row at distal limit of upper lobe.

Rostrum: In both sexes frontal plate produced into short acute rostrum which extends to anterior limit of eye when eye is vertical.

Carapace: Gastric region domed, with short, low, median keel.

3rd thoracic leg: Elongated leg bears false chela typical of *S. longicorne* group, formed of bristles from penultimate and dactyl segments.

Abdomen: 6th segment varies in length, length/depth ratio ranges from 1.63 to 2.35. The "Long" and "Short" forms of this species are distinguished on the basis of whether this proportion is greater or less than 2.0, respectively.

Petasma: Terminal and proximal processes are nearly equal in length. Both bend inward in the direction of spine-shaped process, and are blunt distally. Terminal process serrated or crenulated along distal margin. Lateral process 2/3 length of proximal process, slender and sub-acute.

Length: "Long Form", 7.1–11.3 mm. "Short Form", 6.2–10.3 mm.

Remarks: Two forms, "Long" and "Short," were described (Brinton, 1962a) on the basis of the length/depth ratio of the 6th abdominal segment (Table 5). In the Pacific, the more slender-appearing "Long Form" occupies thermocline depth (Brinton, 1967) along the western margin of the range of the species, submerging somewhat in the western Pacific where it underlies the "Short Form". Hence, both forms apparently occur together in the same water column except in marginal parts of the overall range, for example, the eastern-most Pacific occupied by the "Long Form" and the Arabian Sea-Bay of Bengal regions occupied by a third form:

Stylocheiron longicorne "North Indian Ocean Form" (Figs. 115a, 124c; distribution, fig. 73a). Eye large, 1.0–1.4 mm in length, lower lobe consistently more broad than upper, the ratio of widths varying between 1.24 and 1.42. Propodus of 2nd thoracic leg distally broadened, inflated in appearance. Rostrum acute in both sexes, extending to or beyond anterior limit of eye. 6th thoracic segment long, 2.35–2.60 times as long as deep

Length: 7–12mm.

    The specimens of this form were previously assigned (Brinton and Gopalakrishnan, 1973) to *Stylocheiron indicus*. The present author at that time attached undue significance to the presence of two long spines at the distal outer margin of the terminal segment of the peduncle of the second antenna. These spines, present on the specimens from the northern Indian Ocean, were listed as a character of *S. indicus* by Silas and Mathew (1967). Such paired spines have now been found in all species of the "S. longicorne group" and in *S. carinatum*.

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The petasma of *S. longicorne* "North Indian Ocean Form" is essentially like those of the two other forms (Fig. 125 a, b), but the distal end of the terminal process appears more deeply crenulated, appearing as a row of inward-curving finger-like projections.

The "North Indian Ocean Form" of *S. longicorne* co-occurs with the "Long" and "Short" forms only marginally at the southern limit of its range, ca. 5°N in the Indian Ocean. It appears not to intergrade with those forms. However, it is considered an ecophenotype and not assigned specific status in view of the distributional evidence which shows it occupying the shallow productive stratum overlying the 0^2-depleted waters of the Arabian Sea and Bay of Bengal, an environment abruptly distinct from that occupied by the "Long" and "Short" forms to the south.

Table 5.*
Ranges of Variability in Certain Measurements of the Species and Forms of the "Stylocheiron longicorne Group"

Species	No. crystalline cones in transverse row in upper eye	Length of adult*** (mm)	Length of eye (mm)	Length of eye / Length of body	Width lower part Eye: Width upper part (B/T)	Length / Depth 6th abd. seg. (L/D)
S. microphthalma	2	6.1- 6.9	.49- .54	.079-.087	2.50-3.00	1.46-1.60
S. suhmii	3	5.5- 7.8	.57- .61	.077-.105	3.9 -4.3	1.66-1.69
S. insulare	4-5	6.2- 8.2	.70- .81	.118-.126	3.78-4.16	1.25-1.39
S. affine						
Calif. Current Form	4-6	5.8- 8.3	.67- .89	.101-.119	1.72-1.96	2.03-2.44
East Equatorial Form	4-5	5.7- 8.4	.61- .98	.097-.126	2.02-2.43	2.00-2.32
West Equatorial Form	4-6	5.4- 8.5	.75- .97	.114-.130	1.67-2.16	1.56-1.93
Central Form	5-8	6.0- 8.0	1.00-1.25	.143-.160	1.45-1.74	1.40-1.58
Indo-Australian Form	4	5.5- 7.3	.62- .87	.100-.127	2.26-2.55	1.70-1.92
S. longicorne						
Long Form	9-19	7.1-11.3	.90-1.46	.116-.149	.86-1.37	2.00-2.35
Short Form	7-8	6.2-10.3	.81-1.25	.127-.142	1.00-1.44	1.63-1.98
N. Indian Ocean Form	11-15	7.0-12.0	1.00-1.40	.108-.143	1.24-1.42	2.35-2.60
S. elongatum	13-16	12.5-18.5	1.40-1.67	.092-.126	.96-1.02	4.18-4.29
S. indicus**	14-16	8.2-13.8	.99-1.41	.09-.10	1.46-1.86	2.01-2.53

*After Brinton (1962)
**From Silas and Mathew (1967)
***Measured from tip of rostrum to tip of telson

NORTH INDIAN OCEAN FORM

a

b

LONG FORM

c

Stylocheiron longicorne
SHORT FORM
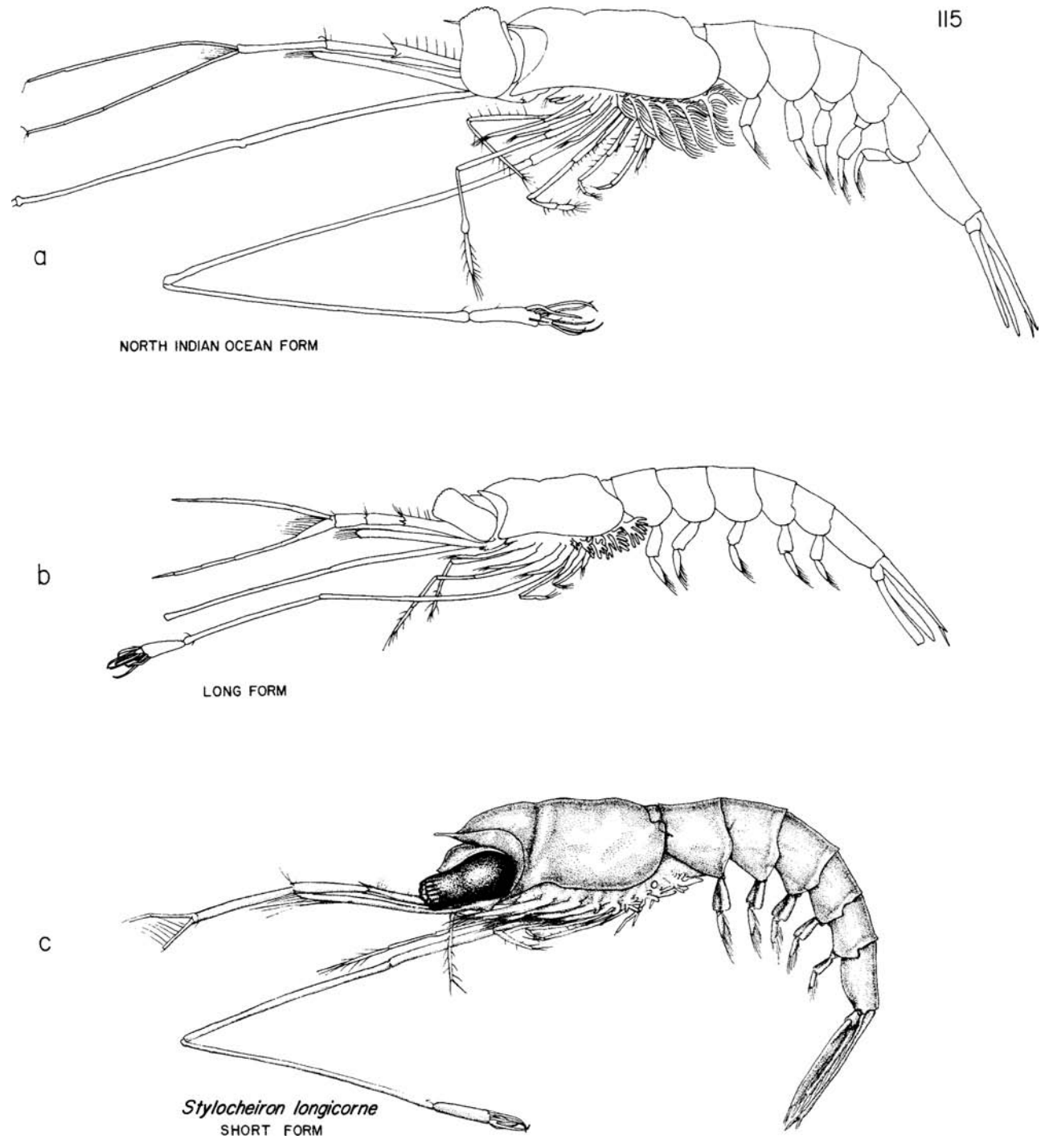
Figure 115. *Stylocheiron longicorne*, a) North Indian Ocean Form, female, b) Long Form, male, c) Short Form, female. (Peduncles and flagella of 1st antennae show sexual differences in *Stylocheiron*.)

Stylocheiron maximum Hansen, 1908

Figs. 116, 124d

S. maximum Hansen, 1908a: 92; 1910: 121–122, pl. xvi, fig. 6, a-d; Banner, 1950: 39–42, pl. iv, fig. 26, a-j; Boden et al., 1955: 391–393, fig. 55.

Eye: Upper, more anterior lobe approximately equal in width of lower lobe, ratio varying from 0.8 to 1.0. No conspicuously enlarged crystalline cones are present, although facets of upper lobe are somewhat larger than those of lower lobe.

Rostrum: Frontal plate produced into an acute rostrum which reaches to anterior limit of eyes.

Carapace: Gastric region domed, with a small median keel.

3rd thoracic leg: Elongated, with dactylus distally pectinate or serrate so as to bear teeth which, juxtaposed to a well-developed spine or immovable finger from penultimate segment, forms a true chela.

Abdomen: No mid-dorsal keels are present. Length/depth ratio for 6th segment is approximately 2.4.

Petasma: Banner (1949) notes variability in certain details of shape of the terminal and proximal process of *S. maximum* from the North Pacific. The same appears to be true among southeast Asian specimens which are relatively small, males being 20–24 mm. Both processes are slightly curved, the terminal being somewhat broader. The distal part of the terminal process is scalloped or spoon-shaped but the tip is acute. The tip of the proximal process is similar to that of the terminal. The lateral process is short and slender, tapering to a sub-acute tip.

Length: 20–30 mm.

Remarks: This is the largest species in the genus. The large size of the eye and the nearly equal width of the two lobes serve further to distinguish *S. maximum* from *S. abbreviatum* and *S. robustum*. Post-larval and immature *S. maximum* strongly resemble *S. abbreviatum*, but the relatively large body size of *S. maximum* at the same stage of development, and the lobe-like, rather than pyriform shape of the upper part of the eye are characteristic of *S. maximum*. While the 6th abdominal segment of adult *S. maximum* is longer than in *S. abbreviatum*, in young specimens the opposite is true, that segment being longer in *S. abbreviatum* until a body length of about 10 mm is reached.

Stylocheiron robustum Brinton, 1962

Figs. 117, 124e

S. robustum Brinton, 1962b: 174–178, figs. 4-5.

Eye: Width of upper lobe, measured at its midpoint, approximately 0.7 that of widest part of lower lobe. Facets of upper lobe scarcely, if at all larger than those of lower lobe. There are no enlarged crystalline cones.

Rostrum: Frontal plate produced as a slender rostrum reaching beyond anterior margin of eyes.
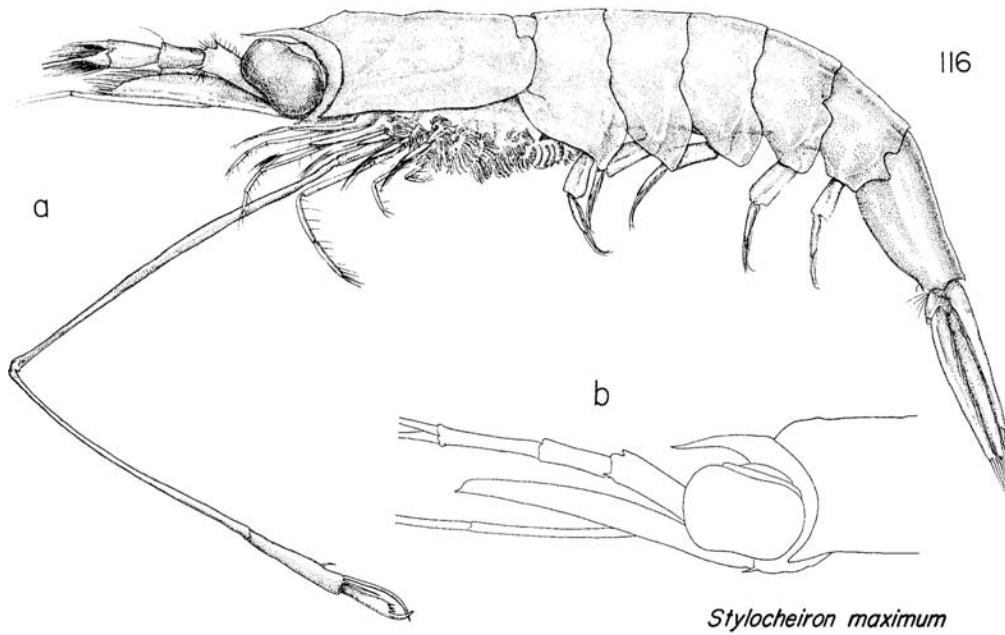
Figure 116. a) *Stylocheiron maximum*, male, b) peduncles of antennae and head region of female.
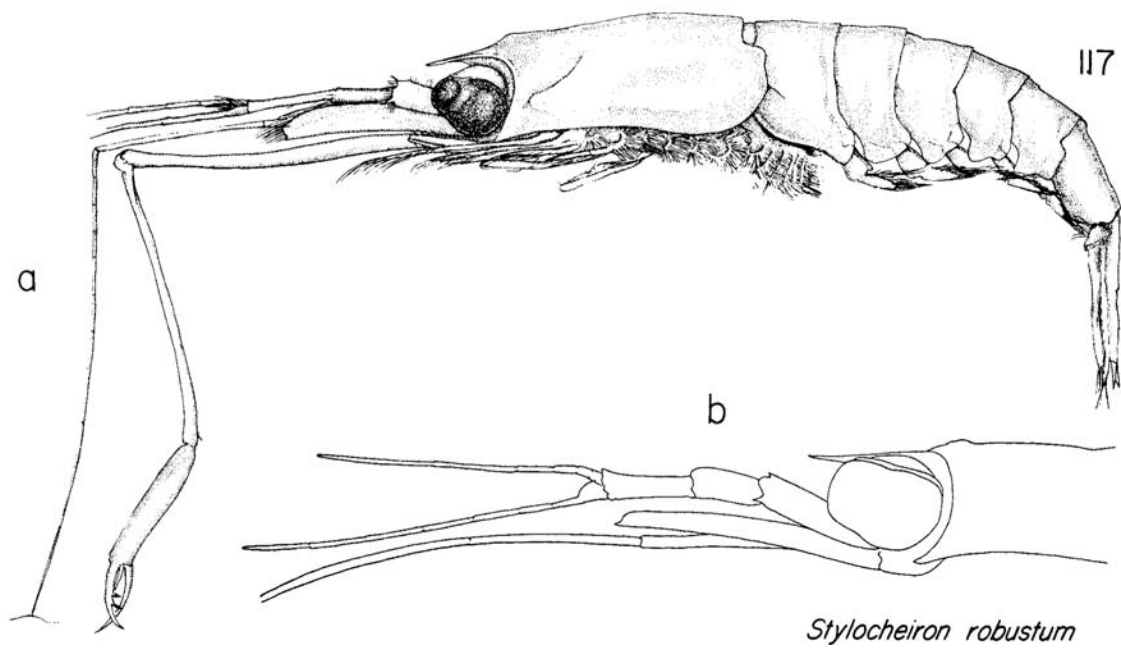
Figure 117. a) *Stylocheiron robustum*, female, b) peduncles of antennae and head region of male.

Carapace: Gastric region domed and bears a small keel anteriorly.

3rd thoracic leg: Elongated leg bears true chela typical of "S. maximum group" (cf. description of *S. maximum*); entire distal half of dactylus occupied by pectinate indentations which give segment its toothed aspect.

Abdomen: No mid-dorsal keels are present. The length/depth ratio for 6th segment is approximately 1.7 to 1.8.

Petasma: Terminal process bends sharply outward distally, ending acutely. Proximal process longer than terminal, and distal 1/3 relatively slender, ending sub-acutely. Lateral process slender, acute and 1/4–1/2 as long as proximal process.

Length: 13–18 mm.

Remarks: *S. robustum* is most similar to *S. abbreviatum* in proportions of the 6th abdominal segment. With respect to the relative widths of the two lobes of the eye it is more similar to *maximum* though the upper lobe is distinctly smaller and narrower than the lower lobe. The body of *S. robustum* is relatively more stocky in overall aspect than in the two other species of the group.

Stylocheiron abbreviatum G.O. Sars, 1883

Figs. 118, 124f

S. abbreviatum G.O. Sars, 1883: 33; 1885: 147–149, pl. xxvii, figs. 11-13; Hansen, 1910: 121–123; 1912: 280–283, pl. xi, fig. 5, a-f; Boden et al., 1955: 390–391, fig. 54. *S. chelifer* Chun, 1896: 162, taf. 1, figs. 1-8; Holt and Tattersall, 1905: 110–112.

Eye: Upper lobe somewhat pyriform in appearance, much smaller than lower lobe. Facets of upper lobe larger than those of lower, but crystalline cones not conspicuously enlarged.

Rostrum: Frontal plate produced as slender rostrum reaching barely beyond anterior limit of eyes.

Carapace: Gastric region domed, with small median keel.

3rd thoracic leg: Elongated leg bears true chela typical of "S. maximum group". Only the distal 1/3 of the dactylus is modified into teeth or pectinate indentations.

Abdomen: 3rd-5th segments bear low mid-dorsal keels. 6th segment length/depth ratio varies from 1.65 to 2.0.

Petasma: Terminal process strong, somewhat hollowed distally. Proximal process shorter, more slender and tapering throughout its length. Lateral process curved, slender, nearly equal in length to proximal process.

Length: 12–17 mm.

Remarks: The narrow pyriform shape of the upper lobe of the eye and the presence of keels on the 3rd-5th abdominal segments distinguish this species from *S. maximum* and *S. robustum*.
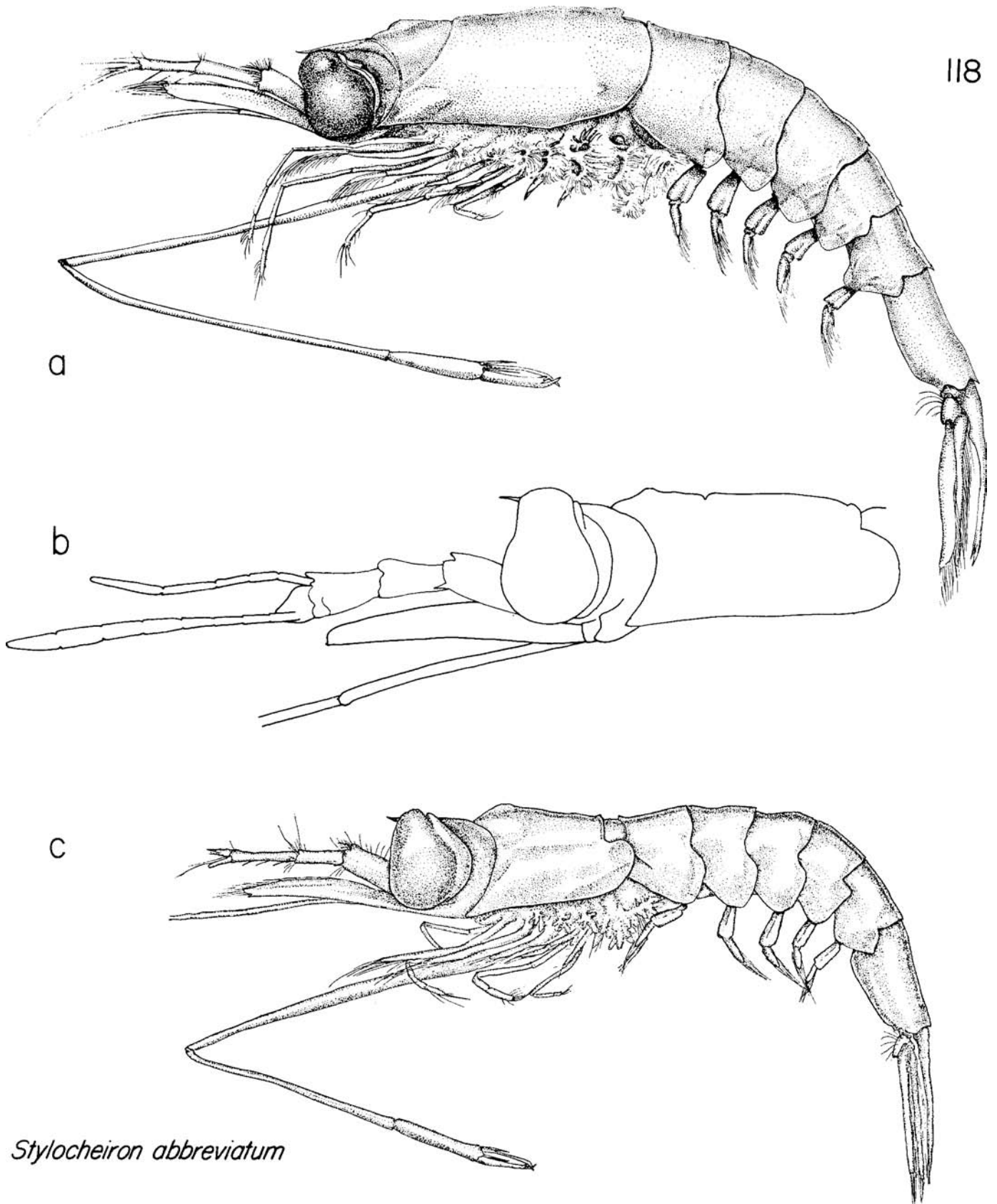
Stylocheiron abbreviatum

Figure 118. a) *Stylocheiron abbreviatum*, female, b) peduncles of antennae and head region of male, c) 7 mm juvenile.

Figure 119. Petasmas, genus *Thysanopoda*.

    a. *T. tricuspidata*, 25 mm, South China Sea.

    b. *T. cornuta*, 102 mm, 22°N, 172°E.

        S-SP, spine-shaped process

        TP, terminal process

        PP, proximal process

        LP, lateral process

        AP^1, AP^2, additional processes

        AL, additional lobe

    c. *T. spinicaudata*, 104 mm, 29°N, 118°W.

    d. *T. egregia*, 43 mm, 40°N, 149°W.

    e. *T. cristata*, 40 mm, Philippine Sea.

    f. *T. pectinata*, 34 mm, South China Sea.

    g. *T. mnnacantha*, 30 mm, South China Sea.

    h. *T. orientalis*, 34 mm, South China Sea.

    i. *T. microphthalma*, 27 mm, 9°W, 0°.

    j. *T. acutifrons*, 34 mm, 43°N, 150°W.

    k. *T. obtusifrons*, 22 mm, Philippine Sea.

a. *T. tricuspidata*

b. *T. cornuta*

c. *T. spinicaudata*

d. *T. egregia*

e. *T. cristata*

f. *T. pectinata*

g. *T. monacantha*

h. *T. orientalis*

i. *T. microphthalma*

j. *T. acutifrons*

k. *T. obtusifrons*

223
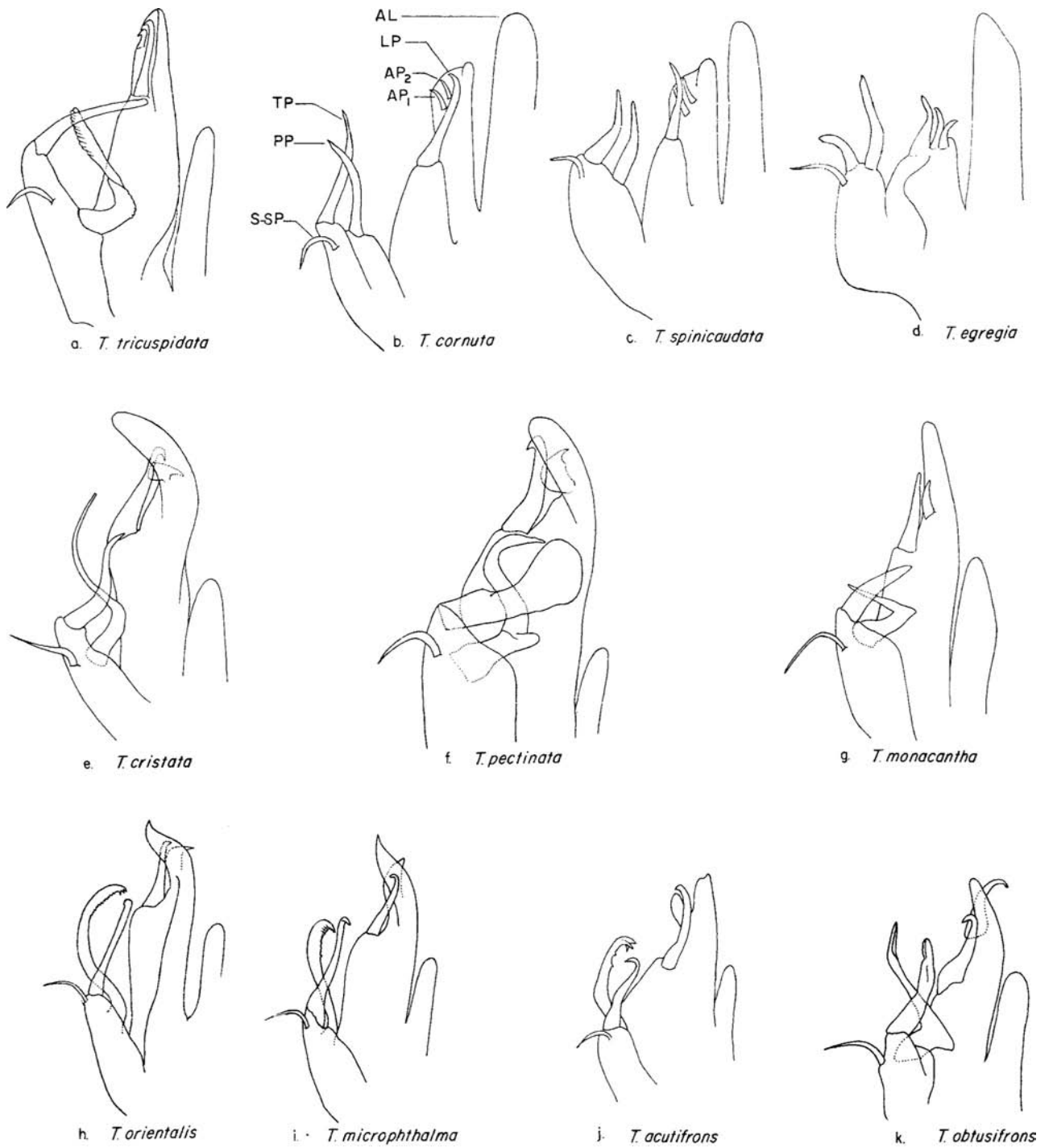
Figure 119. Petasmas, genus *Thysanopoda*, continued.

l. *T. aequalis*, 15 mm, Indian Ocean.

m. *T. aequalis*, 16 mm, South China Sea.

n. *T. astylata*, 15 mm, California Current.

o. *T. astylata*, equatorial Pacific, 160°W.
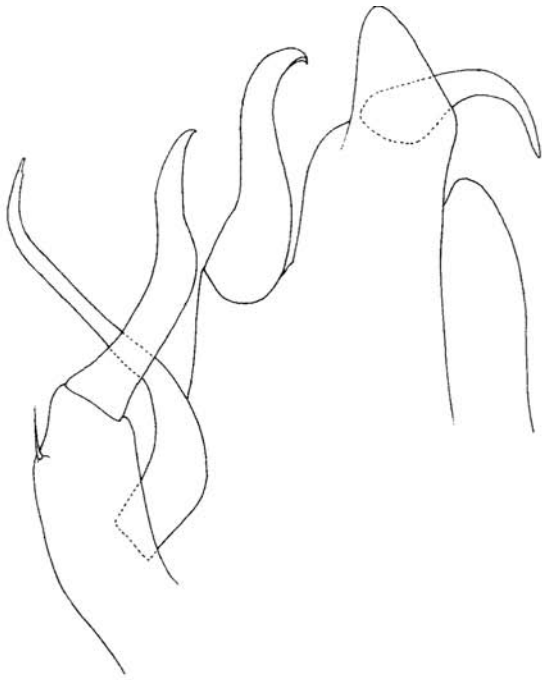
l. *T. aequalis*
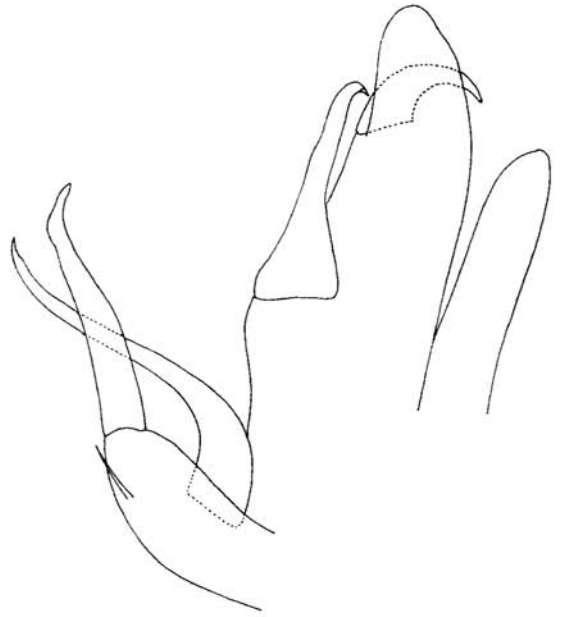
n. *T. astylata*
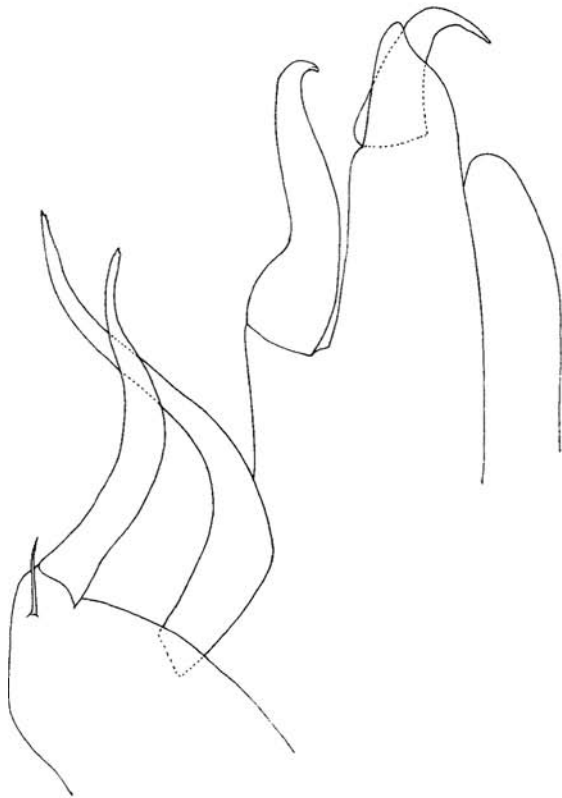
m. *T. aequalis*

o. *T. astylata*

225
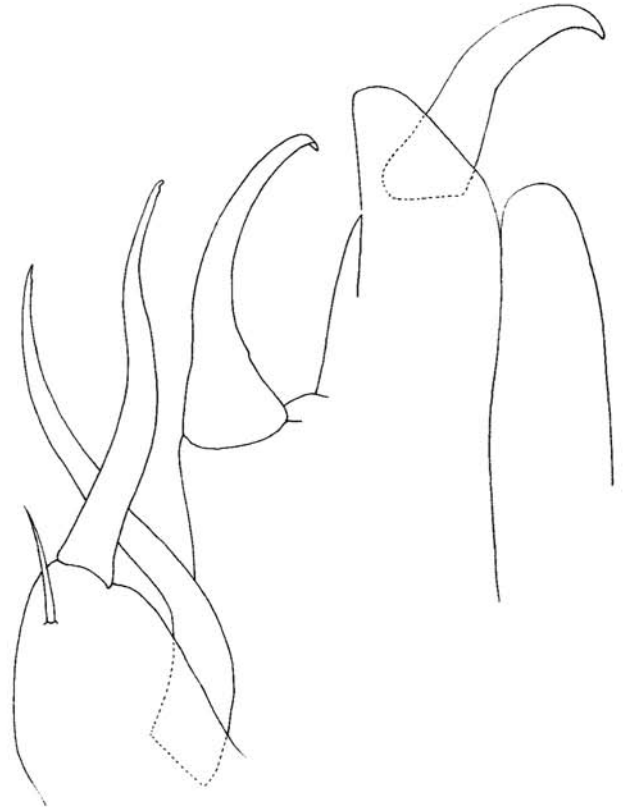
Figure 120. Petasmas, genus *Euphausia*.

a. *E. muitica*, 10 mm, South China Sea.

b. *E. brevis*, 9 mm, Philippine Sea.

c. *E. recurva*, 10 mm, Philippine Sea.

d. *E. diomedeae*, 11 mm, South China Sea.

e. *E. similis*, 24 mm, South China Sea.

f. *E. tenera*, 8 mm, South China Sea.

g. *E. sibogae*, 7 mm, Celebes Sea.

h. *E. pseudogibba*, detail of lateral process.

i. *E. pseudogibba*, 11 mm, South China Sea.

j. *E. hemigibba*, 11 mm, South China Sea.

k. *E. paragibba*, detail of lateral process.

l. *E. paragibba*, 12 mm, western equatorial Pacific.

m. *E. gibba*, 11 mm, Coral Sea.
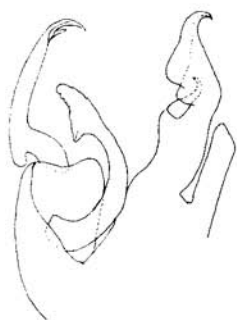
a. *E. mutica*
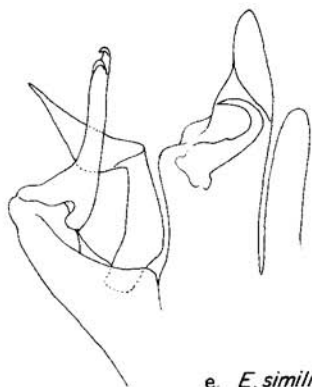
e. *E. similis*

h.
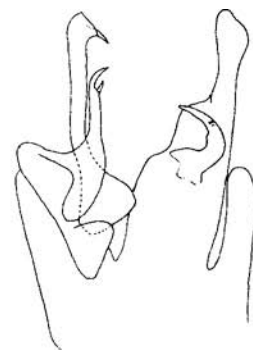
i. *E. pseudogibba*
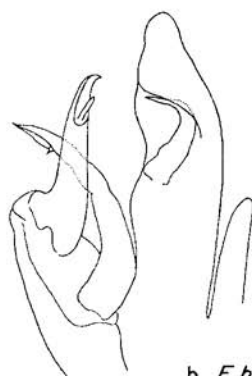
b. *E. brevis*

f. *E. tenera*
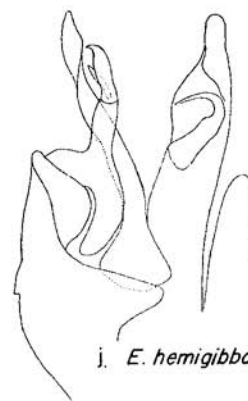
j. *E. hemigibba*

c. *E. recurva*

k.

l. *E. paragibba*

setiferous lobe

additional lobe

median lobe

lateral process

proximal process

terminal process

inner lobe
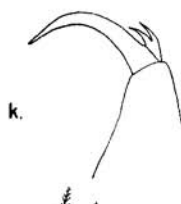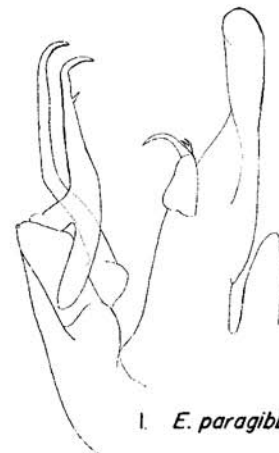
d. *E. diomediae*
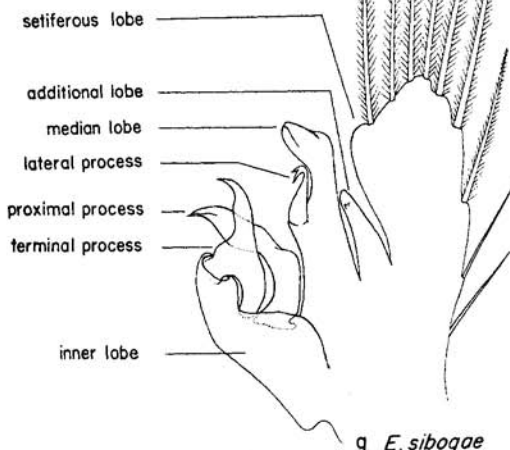
g. *E. sibogae*
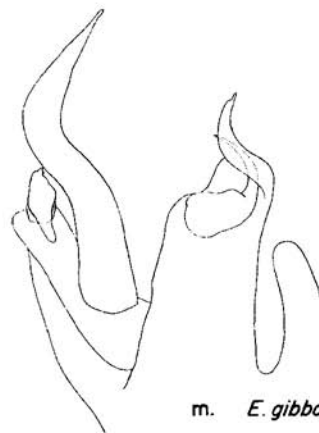
m. *E. gibba*

Figure 121. Petasmas, "Euphausia gibboides group" and *Pseudeuphausia latifrons*.

a. *E. gibboides*, 16 mm, eastern tropical Atlantic.

b. *E. gibboides*, 18.5 mm, California Current.

c. *E. sanzoi*, 16.5 mm, South China Sea.

d. *E. sanzoi*, Philippines, detail of terminal process.

e. *E. sanzoi*, Somali Current, endopods of 1st pair of male pleopods from behind, petasma rolled against setiferous lobe as in swimming position.

f. *E. fallax*, Philippines, detail of terminal process.

g. *E. fallax*, 15 mm, Philippines.

h. *Pseudeuphausia latifrons*, 9 mm, South China Sea.
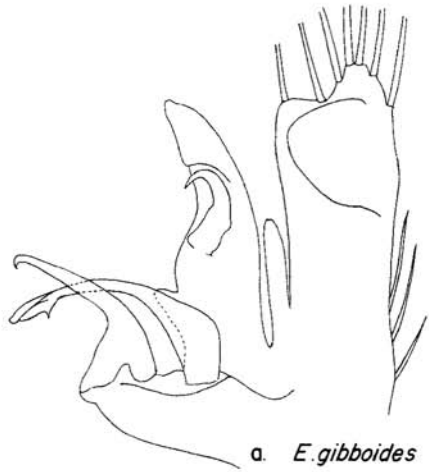
a. *E.gibboides* (Atlantic)

b. *E.gibboides* (Pacific)

c. *E.sanzoi*

d. *E.sanzoi* TP

e.
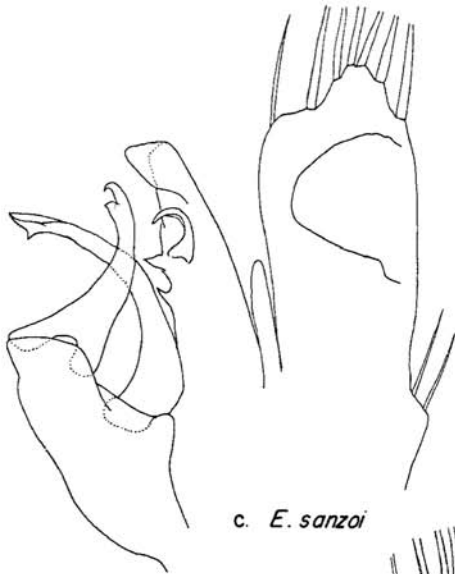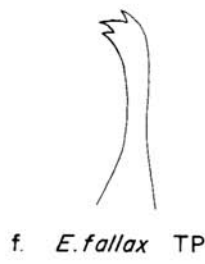
f. *E.fallax* TP
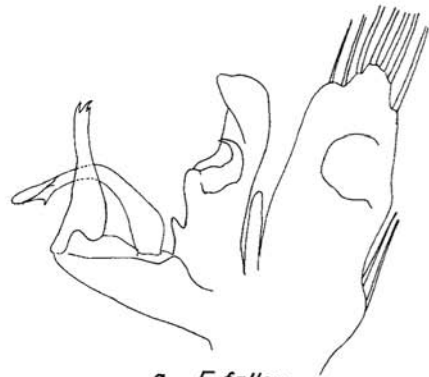
g. *E.fallax*
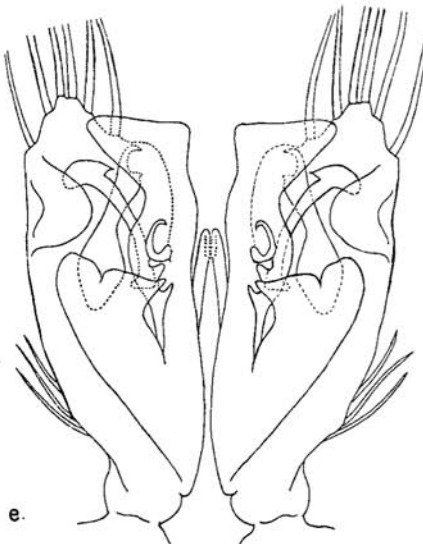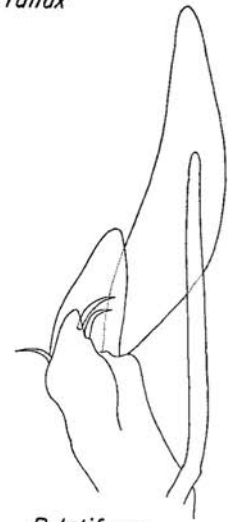
h. *P.latifrons*

Figure 122. Petasmas, genus *Nematoscelis* and genus *Nematobrachion*.

    a. *Nematoscelis tenella*, 16 mm, Philippine Sea.

    b. *N. gracilis* "Old Form" (Gopalakrishnan, 1973b, in press), 11 mm, South China Sea.

    c. *N. microps*, 12.5 mm, South China Sea.

    d. *N. atlantica*, 12 mm, Philippine Sea.

    e. *N. lobata*, 12 mm, Sulu Sea.

    f. *Nematobrachion flexipes*, 23 mm, Philippine Sea.

    g. *N. sexspinosus*, 24 mm, Philippine Sea.

    h. *N. boöpis*, 22 mm, Philippine Sea.
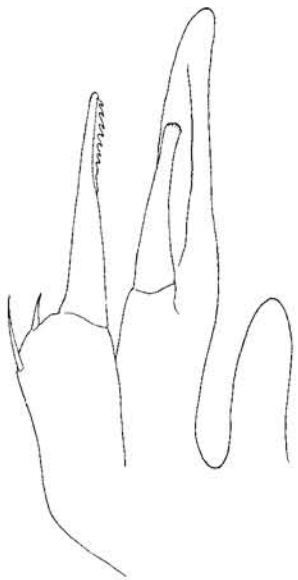
a. *N. tenella*
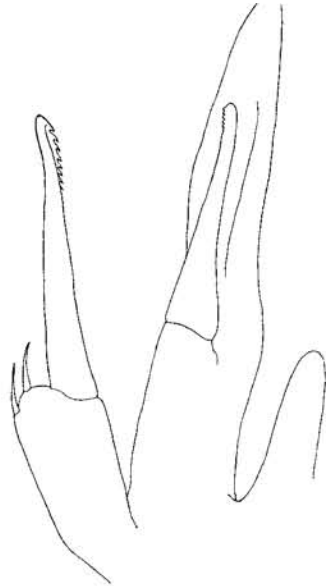
b. *N. gracilis*
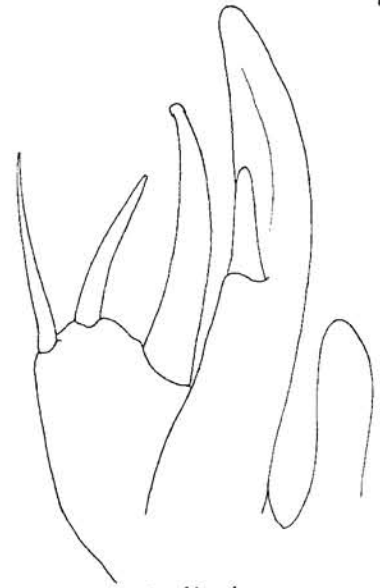
c. *N. microps*
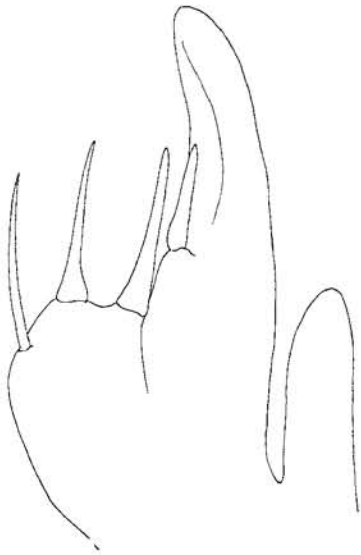
d. *N. atlantica*
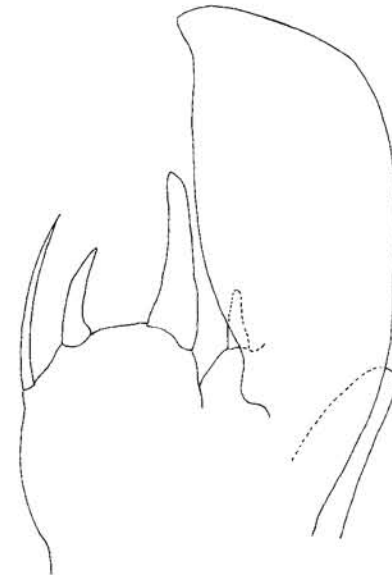
e. *N. lobata*

f. *N. flexipes*
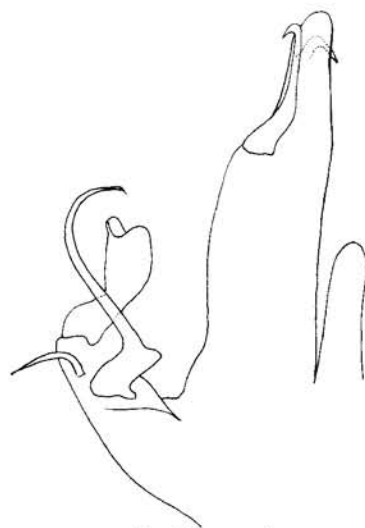
g. *N. sexspinosus*
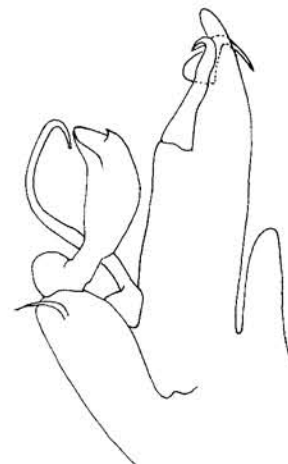
h. *N. boöpis*

Figure 123. Petasmas, genus *Stylocheiron*.

    a. *S. carinatum*, 7 mm, South China Sea.
    b. *S. suhmii*, 6.5 mm, South China Sea.
    c. *S. insulare*, 6.5 mm, Banda Sea.
    d. *S. affine* West Equatorial Form, 6.5 mm, South China Sea.
    e. *S. affine* Indo-Australian Form, 6.5 mm, South China Sea.
    f. *S. affine* Central Form, 6.5 mm, Philippine Sea.
    g. *S. microphthalma*, 6 mm, South China Sea.
    h. *S. indicus*, 11 mm, Arabian Sea (after Silas and Mathew, 1967).
    i. *S. elongatum*, 12 mm, Philippine Sea.

a. *S. carinatum*

b. *S. suhmii*

c. *S. insulare*

d. *S. affine*
    (West Equatorial Form)

e. *S. affine*
    (Indo-Australian Form)
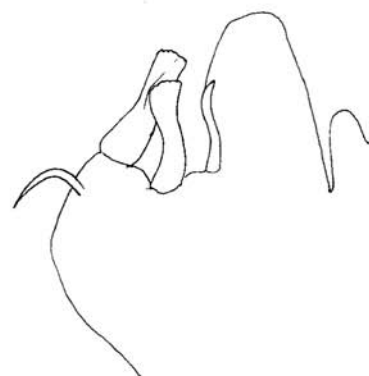
f. *S. affine*
    (Central Form)

g. *S. microphthalma*

h. *S. indicus*
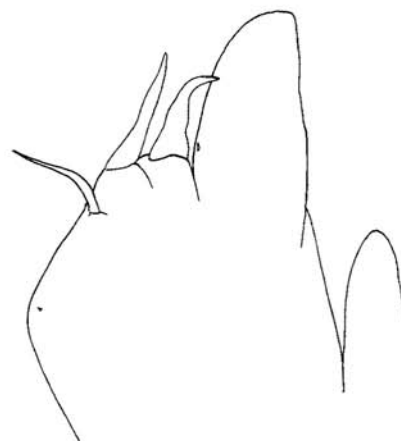
i. *S. elongatum*

Figure 124. Petasmas, genus *Stylocheiron*, continued.

      a. *S. longicorne* Short Form, 7.5 mm, South China Sea.

      b. *S. longicorne* Long Form, 8 mm, Philippine Sea.

      c. *S. longicorne*, North Indian Ocean Form, 10 mm, Andaman Sea.

      d. *S. maximum*, 24 mm, Philippine Sea.

      e. *S. robustum*, 14 mm, Philippine Sea.

      f. *S. abbreviatum*, 14 mm, Philippine Sea.
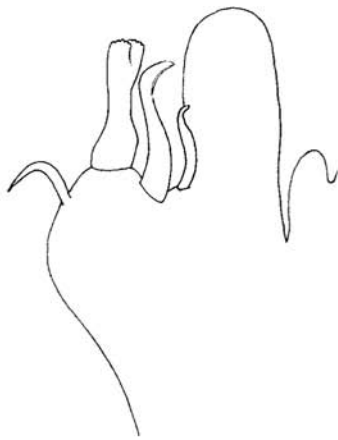
a. *S. longicorne*
(Short Form)
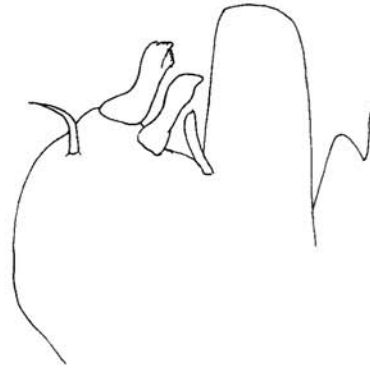
b. *S. longicorne*
(Long Form)

c. *S. longicorne*
(North Indian Ocean Form)

d. *S. maximum*
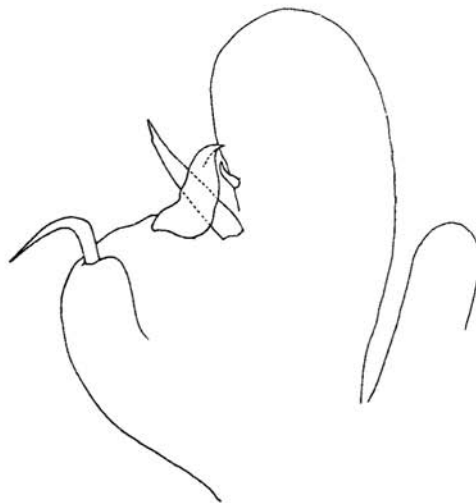
e. *S. robustum*
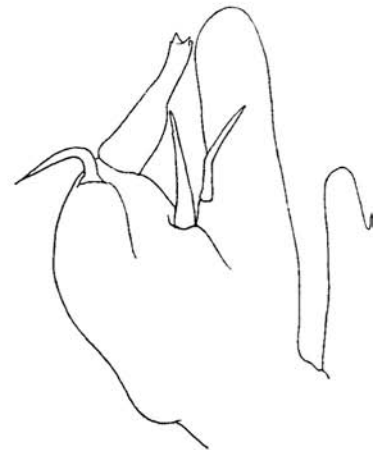
f. *S. abbreviatum*

THE LARVAL FORMS

Drawings of the larvae of some species occurring in southeast Asian waters are included here. In eleven of the species, several stages of development are shown. In four other species one stage only has been illustrated. The drawings are presented as aids in the recognition and identification of specimens, and are inadequate as studies of larval development.

As far as is known, euphausiids consistently pass through four larval phases, each made up of one or more stages (instars). The following are characteristics of these phases, simplified after Sars (1885), Einarsson (1945), Sheard (1953) and Gopalakrishnan (1973). Mauchline and Fisher provide a full summary of what was known of development in euphausiids until 1969.

Nauplius phase. Three pairs of appendages, each about equal in length. First antennae uniramous, presumed to be sensory; second antennae and mandibles biramous, used in swimming. Body ovoid to pear-shaped. Two stages. (Free-floating eggs hatch into this phase.)

Metanauplius phase. Mandibles shortened to rudimentary buds. Two anterior limbs as in nauplius. Carapace developed, covering anterior part of body. Abdomen (unsegmented) emerging, usually with posterior spines. One stage. (Eggs carried externally by female hatch as pseudo-metanauplius which develops into metanauplius without molting.)

Calyptopis phase. Carapace large with eyes developing beneath it. Abdomen becomes segmented. Uropods differentiate. Three stages.

Furcilia phase. Eyes extend from beneath carapace. Second antennae may change in form and in function from swimming to sensory. Thoracic limbs and pleopods develop. Pleopods progressively added until full complement of five setose pleopods is present ($1'$ = pleopod without setae; $1''$ = pleopod with setae). Fraser (1936) showed that a setose pleopod develops, a moult later, from a nonsetose pleopod. Most commonly observed sequence of pleopod development, for example, $0 \longrightarrow 1' \longrightarrow 1''2' \longrightarrow 3''2' \longrightarrow 5''$ in *Stylocheiron,* is comprised of "dominant stages," following MacDonald (1927), and infrequently occuring stages are termed "variants." Terminal telson speines progressively reduced in number. Variable number of stages.

The juvenile phase begins when the telson has one terminal and two postero-lateral spines as in adult and the antenna is altered in form. It ends at sexual maturity.

No tropical or subtropical euphausiid has been reared from larva to adult. Therefore, the duration of the juvenile phase for such epipelagic species may only be approximated as of the order of two to five months. The temperate Pacific species *Euphausia pacifica* becomes mature after three to five months off Southern California (Brinton, MS) and after four to five months off Oregon (Smiles and Pearcy, 1971), the larval period having lasted about one month (as also was found for warm-temperate *Nematoscelis difficilis* by Gopalakrishnan. 1973a).

The onset of adulthood occurs at reproductive maturity. Secondary sexual characteristics appearing at this time include the male petasma (endopod of first pleopod). the spine-like modification of the third thoracic endopod in *Thysanopoda aequalis* (Fig. 89b), and the sexually dimorphic lappet on the antennular peduncle in *Euphausia recurva* (Fig. 94). Adulthood apparently lasts for several months in most species, during which time growth continues. Studies of life-span in tropical species have not been attempted. Estimates for various high latitude species range from three years (e.g., Ruud, 1932; Bargmann, 1945; Einarsson, 1945; Nemoto, 1957; Baker, 1959; Mauchline, 1960) to one year in warm-temperate *Euphausia pacifica* (Smiles and Pearcy, 1971; Brinton, MS).

Larval stages of several of the species occurring in the study area have received attention in the literature. The descriptions differ greatly in detail and in completeness, ranging from the *Challenger* (Sars, 1885), *Siboga* (Hansen, 1910), *Albatross* (Hansen, 1912) and *Valdivia* (Illig, 1930) expedition reports in which various examples of larvae are depicted, to the developmental sequences shown first by Lebour (1926a, 1926b, Mediterranean Sea; 1949, Bermuda) and most recently by Lewis (1955, Florida Straits) and Casanova (1974, Mediterranean Sea). Sequences shown by Gurney (1947, Atlantic), Sheard (1953, eastern Australia) and Ponomareva (1969, Indian Ocean) are also relevant. All observations of pleopod succession are summarized by Mauchline and Fisher (1969).

Larval development, particularly of appendages, setation and body proportions, are considered thoroughly by Gopalakrishnan (1973a) for *Nematoscelis difficilis*, and Knight (1973, 1975, MS) for *Thysanopoda tricuspidata* and the three species of the "Euphausia gibboides group." Precise details of structure are provided, making the reports valuable not only for identification but in ontogenetic and phylogenetic considerations. Wang (1965) provided clear details of larval stages of *Pseudeuphausia sinica.*

Descriptions and illustrations present in the literature pertaining to the tropical-subtropical Indo-Pacific species are referred to in the annotated synonomies below. Larvae of species inhabiting Arctic, Antarctic, and temperate seas, some of which have been described in substantial detail (e.g., by Fraser, 1936; MacDonald, 1927, 1928; John, 1936; Einarsson, 1945; Boden, 1950, 1951; Bary, 1956; Ponomareva, 1959) are not included in this list.

Bentheuphausia amblyops

Tattersall, 1926: 12-13. A specimen 10mm in length is described as having posterior half of lower free margin of carapace serrate.

Illig, 1930: 494, figs. 178-181. Two specimens 7.5, 16 mm, possess serrated posteriorlateral margin of carapace, otherwise resembling juveniles. Lateral and dorsal views provided of head of 7.5 mm specimen, most thoracic legs broken off or undeveloped. Lateral view of carapace of 16 mm specimen.

Thysanopoda tricupsidata. Fig. 125.

Sars, 1885: 165-169, p1. xxi, figs. 17-22. Two calyptopis, two furcilia and one cyrtopia (post larva) stages described and figured. Mandible, maxilla and first thoracic leg figured for last calyptopis. Telson spination of six developmental stages depicted.

Tattersall, 1912: 135-136. Brief corroboration of Sars' illustrations and description.

Gurney, 1947: 49-64. Pleopod succession explained as 0, 2′, 2″, 4″1′, 5″, with variants probable.

Lebour, 1949: 828-829. Two cyrtopia specimens recorded. High variability in pleopod succession discussed, based on nine known variants, dominant stages being still unknown.

Pillai, 1957: 1-28. Late larvae illustrated.

Knight, 1973: 53-67, figs. 1-9. Complete illustration and description of nauplius II, the ornate netanauplius (here first recognized), and three calyptopis stages. Details of appendage development and phylogenetic considerations are significant.

Cyrtopia rostrata, Dana, 1852, (fide Sars, 1885). The particularly distinctive larvae of *T. tricuspidata* are here first recognized. They are interpreted as a distinct genus.

One calyptopis stage and three different furcilia (Fig. 125) are shown here (pleopods: 0, 2′, 1″3′), and not identified with respect to stage.

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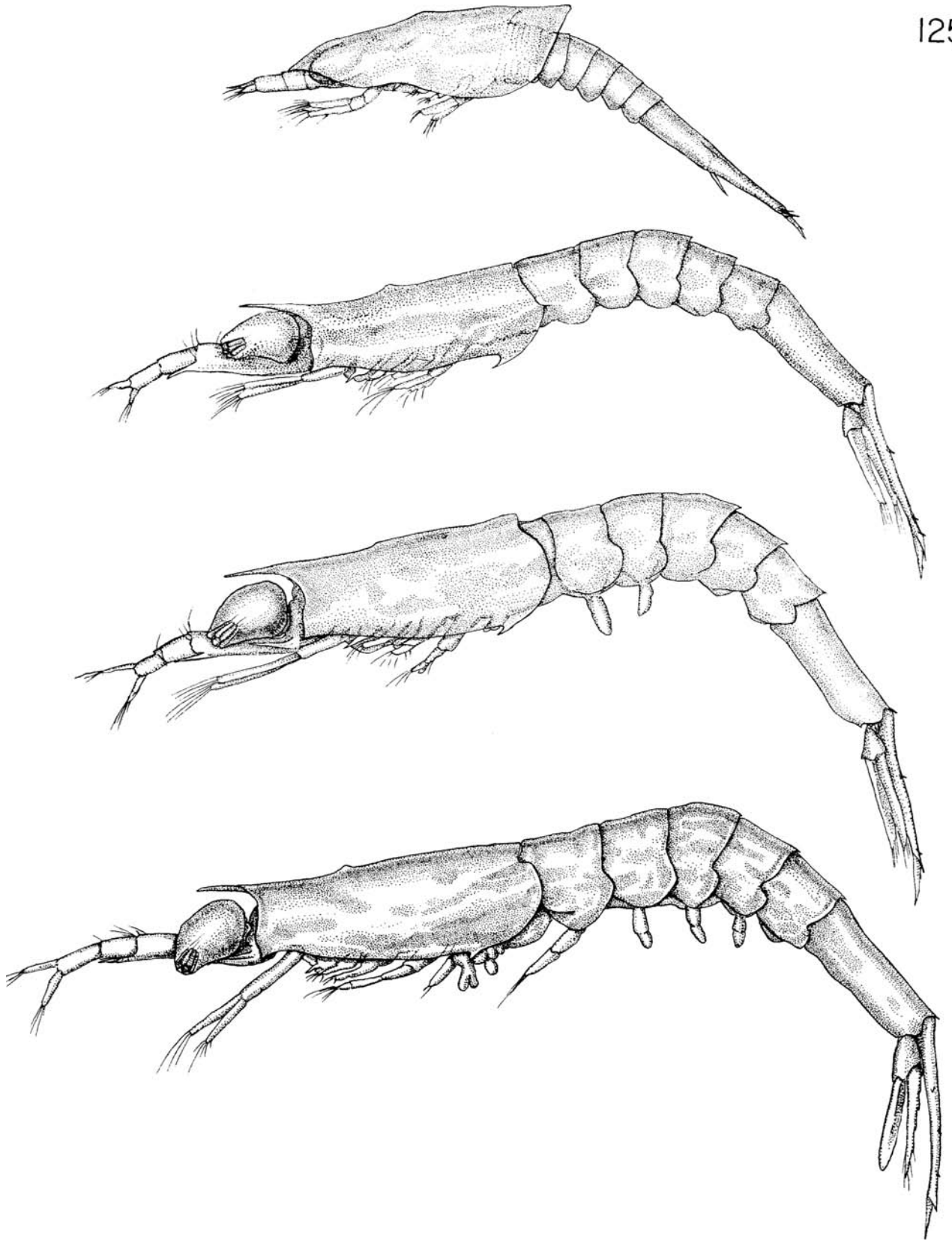
Figure 125. *Thysanopoda tricuspidata* larvae. Calyptopis stage (2.5 mm) and furcilia stages (3.6, 5.1 and 5.5 mm), from South China Sea.

Thysanopoda cornuta (and *T. spinicaudata*?). Fig. 126.

> Einarsson, 1945: 14. Pleopod succession given as 4′, 4″1′, 5″; no other details.

> Brinton, 1962a: 79-81, Table 3. Ten larvae (4.6-10 mm) and seven "cyrtopia" (12-17 mm) tabulated with respect to pleopod development (0, 4″, 5″) and terminal telson spines. Developmental series show these to be *cornuta* (Tattersall's "Species B").

> *T. cornuta?*, Tattersall, 1972: 15-16, p1. 2, figs. 9-11 ("?"Tattersall's). Five specimens 8-13 mm. The 13 mm specimen is figured in dorsal and lateral views with large rostral spine, no carapace "ripple markings."

> *T. sp.*, Illing, 1930: 518-520, figs. 207-209. Two 16 mm specimens. Dorsal, lateral and telson views figured.

> *T. sp.* (cornuta group), Tattersall, 1939: 214-215. Two specimens, 9 and 13 mm. Tattersall assigns these to a "Species B", opposed to a "Species A" having carapace "ripple markings" and short rostral spine.

The 12.5 mm specimen figured here has a single terminal telson spine and five setose pleopods. The posterior thoracic legs are not developed. The antennae are unsegmented.

It is possible that the above specimens include some of *T. spinicaudata.*

Thysanopoda egregia. Fig. 127.

> Brinton, 1962a: 70-81, Table 3. Fifty-one larvae, 4.6 to 13 mm in length, tabulated with respect to pleopod development (3″, 3″1′, 4″1′, 5″) and telson spination. Seven post-larvae are 13 to 18 mm in length. Developmental series show these to be *egregia,* with carapace "ripple markings" and broad rostral plate with short rostral spine (Tattersall's, 1939, "Species A").

> (?)*T. cornuta,* Hansen, 1912: 224-225, p1. vi, figs. 1a-e. ("?" Hansen's). One specimen 14.5 mm figured in dorsal head view, maxillae and telson (single terminal spine). Size established it as "late in larval life" as Hansen supposed.

> *T. sp.*, Zimmer, 1914: 419-422, figs. 55-58. The first description of the large (5.5-10 mm) furcilia with carapace "ripple markings". Dorsal and lateral views.

> *T. cornuta,* larva only, Illig, 1930: 514-517, figs. 199-204. One specimen 14.5 mm figured in dorsal and lateral views, maxillae, telson (seven terminal spines). Second specimen, 6 mm, telson figured (eight terminal spines).

The 9 mm specimen figured here (Fig. 127) has seven terminal telson spines, pleopods 5″, thoracic legs incomplete, antennae unsegmented.

Thysanopoda cristata. Fig. 128.

> Gurney, 1947: 52-53, fig. 2. Telson spine succession through furcilia stages is illustrated. A furcilia II is shown in lateral view. Pleopod succession given as follows: Furc. I (5.56 mm) 3′; Furc. II (6.75 mm) 3″ 1′; Furc. III (7 mm) 5″. The long rostrum and the bilobed eye suggest that these specimens are either *T. pectinata or T. cristata.*

The post-larva illustrated here is 9.5 mm in length. It is characterized by 1) the long acute rostrum, 2) bilobed eye, 3) high mid-dorsal keel on carapace. which drops down sharply posterior to its peak, and 4) posterior extensions of the mid-dorsal parts of the 3rd and 4th abdominal segments. The young of *cristata* resemble *pectinata,* but are larger, with a more conspicuous dorsal carapace keel.
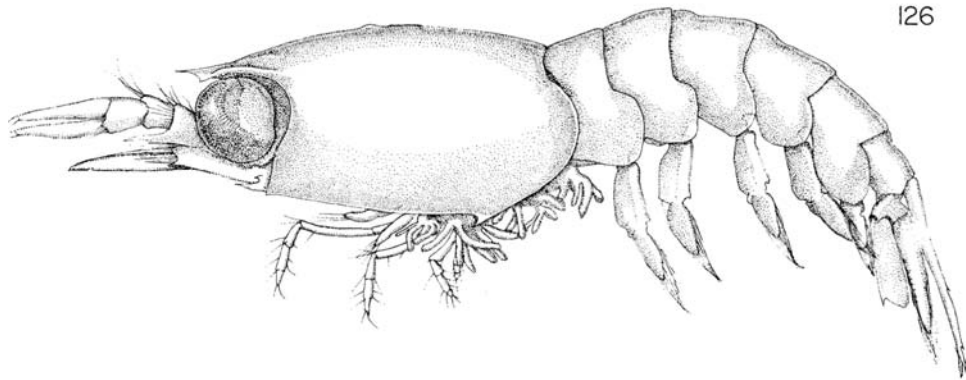
Figure 126. *Thysanopoda cornuta,* late larva, 12.5 mm, from Philippine Sea.
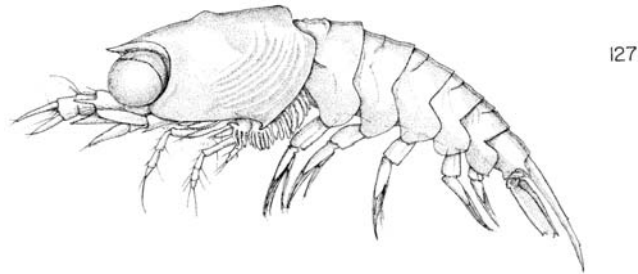
Figure 127. *Thysanopoda egregia,* late larva, 9 mm, from South China Sea.
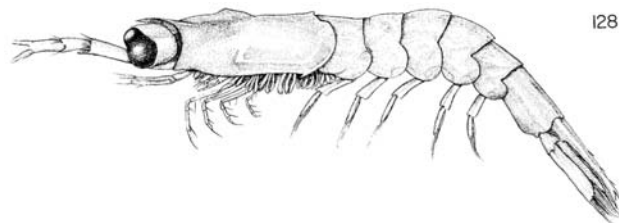
Figure 128. *Thysanopoda cristata, juvenile,* 9.5 mm, from Philippine Sea.

Thysanopoda pectinata. Fig. 129.

> Hansen, 1912: 220-222, plate 6, fig. 1k-m. A post-larval specimen of 11 mm is figured. The bilobed eye of the juvenile is evident and the lappet of the 1st antennular segment is already pectinate.

> Illig, 1930: 510-511, figs. 192-193. A post-larval specimen of 15 mm is figured, possessing bilobed eye, long rostral plate, and pectinate antennular lappet. The dorsal part of the 3rd abdominal segment is somewhat extended posteriorly, but this is also a characteristic of larvae and post-larvae of *T. cristata and T. monacantha.*

> Einarsson, 1945: 45. Species is alluded to only with respect to pleopod succession, given as 3′, 3″2′ 5″.

The southeast Asian specimens figured are a calyptopis, three furcilia (pleopod succession 3′, 3″2′, 5″) and a 10 mm juvenile. The long, nearly straight rostrum, the bilobed eye, together with the low, short carapace keel are aids in identification. The small keel differs from the larger one of *T. cristata.*

Thysanopoda obtusifrons

> *T. aequalis?* Species B, Gurney, 1947: 53-54, fig. 3. These specimens closely resemble furcilia of *T. aequalis-astylata.* The rostral plate is shown as narrower than in Gurney's Species A, and the eye coloration is lighter. The specimens of Species B are somewhat larger.

The illustrations closely resemble furcilia of *T. obtusifrons* from the region of the present study. The very lightly pigmented eye, with the facets none-the-less distinct, is characteristic.
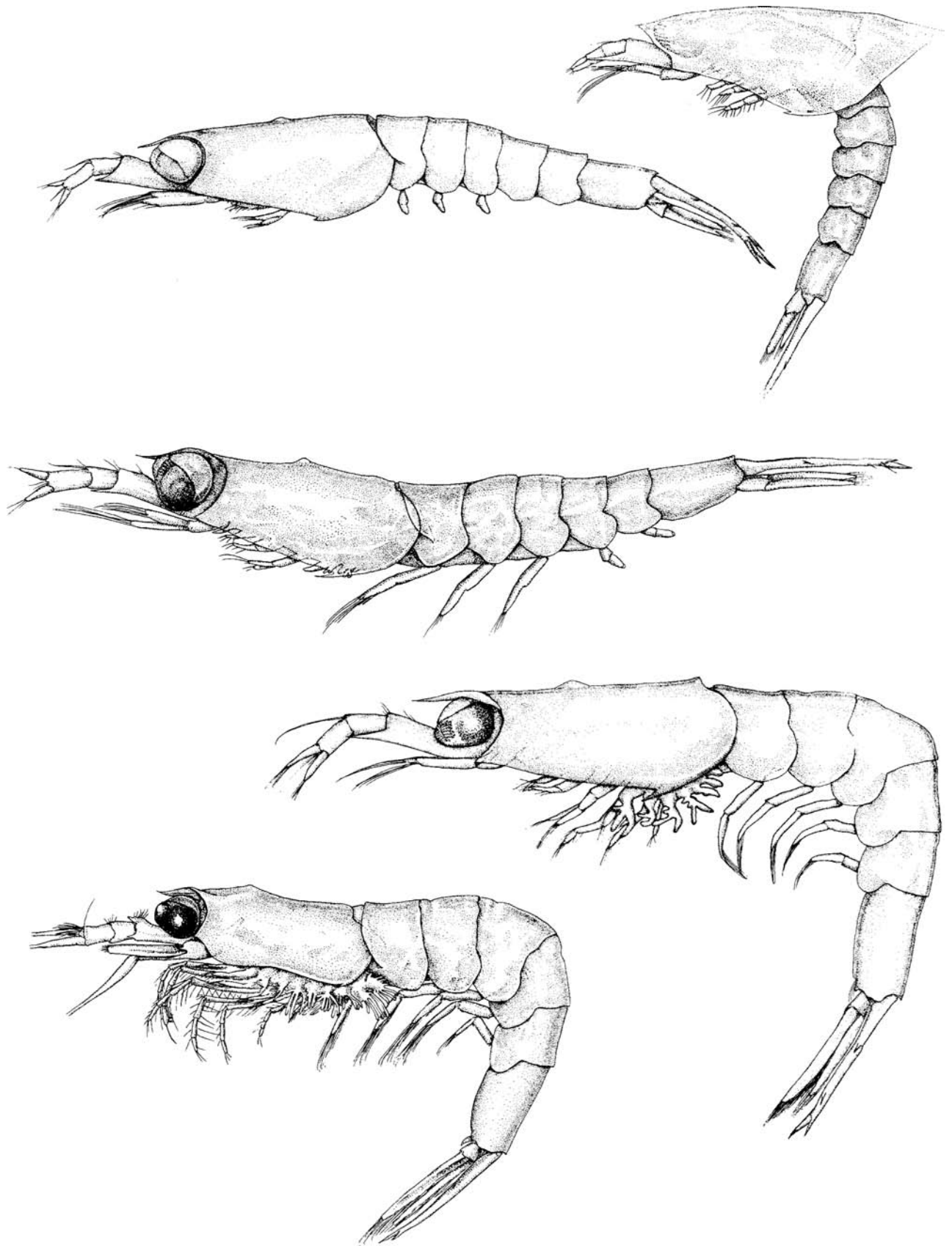
Figure 129. *Thysanopoda pectinata* larvae and juvenile. Calyptopis stage (4 mm), furcilia stages (4.3 mm, 5.1 mm and 7.0 mm), juvenile (10 mm), from South China Sea.

Thysanopoda monacantha. Fig. 130.

T. Agassizii, Ortmann, 1894: 99-100, plate figs. 1, 2. Two juvenile specimens, now known to be *T. monacantha,* were described. The larger, 19 mm, is figured with a perfectly round eye, a character assumed in the juvenile phase. Other juvenile characters include the acute rostrum and spine-like mid-dorsal projections on 3rd-5th abdominal segments.

T. Agasizzii, Hansen, 1910: 88-89, plate xlll, figs. 3c-g. Larva of 4.7 mm is figured in dorsal view, and telson. Eyes described as large, black, nearly round. Hansen notes that this may be *monacantha.*

T. sp. (*T. monacantha* Ortmann. aff.), Hansen, 1912: 284-287, plate 12, fig 1a-g. Two furcilia stages well illustrated, dorsal and lateral views. Pleopods are 1″ and 2″2″ for 3.7 and 5 mm specimens respectively.

T. cristata, Lebour, 1949: 829-830, fig. 2, 3-7. A second furcilia (pleopods 1″2′) is figured as posessing round black eyes, a characteristic only of *T. monacantha.* The 4.7 mm calyptopis may also be *monacantha,* but its slenderness suggests *orientalis or pectinata.*

The specimens figured here show the very large carapace of the calyptopis phase, the humped and posteriorly projecting 2nd abdominal segment of the furcilia phase. The blackened portion of the eye is very slightly lobed, usually anteriorly. Pleopod sequences in the figured furcilia (presumably stages II, III and IV) are 2″2′, 4″1′, 5″.

Thysanopoda orientalis

Hansen, 1910: 86-87, plate xlll, figs. 2d-i. Specimens of 5.7 and 10 mm are figured, showing bilobed eye characteristic of young, with dorsal and lateral views and telson.

Lebour, 1949: 830, fig. 2, 8-11. Small figures provided of furcilia with pleopod formula 3″2′.

The detailed report by Einarsson (1945) on larval development of the related species *T. acutifrons provides* illustrations useful in recognizing larvae of the *acutifrons-orientalis-microphthalma* group. Two calyptopis and eight furcilia stages are figured. The pleopod succession is 3′, 3″2′, 5″.
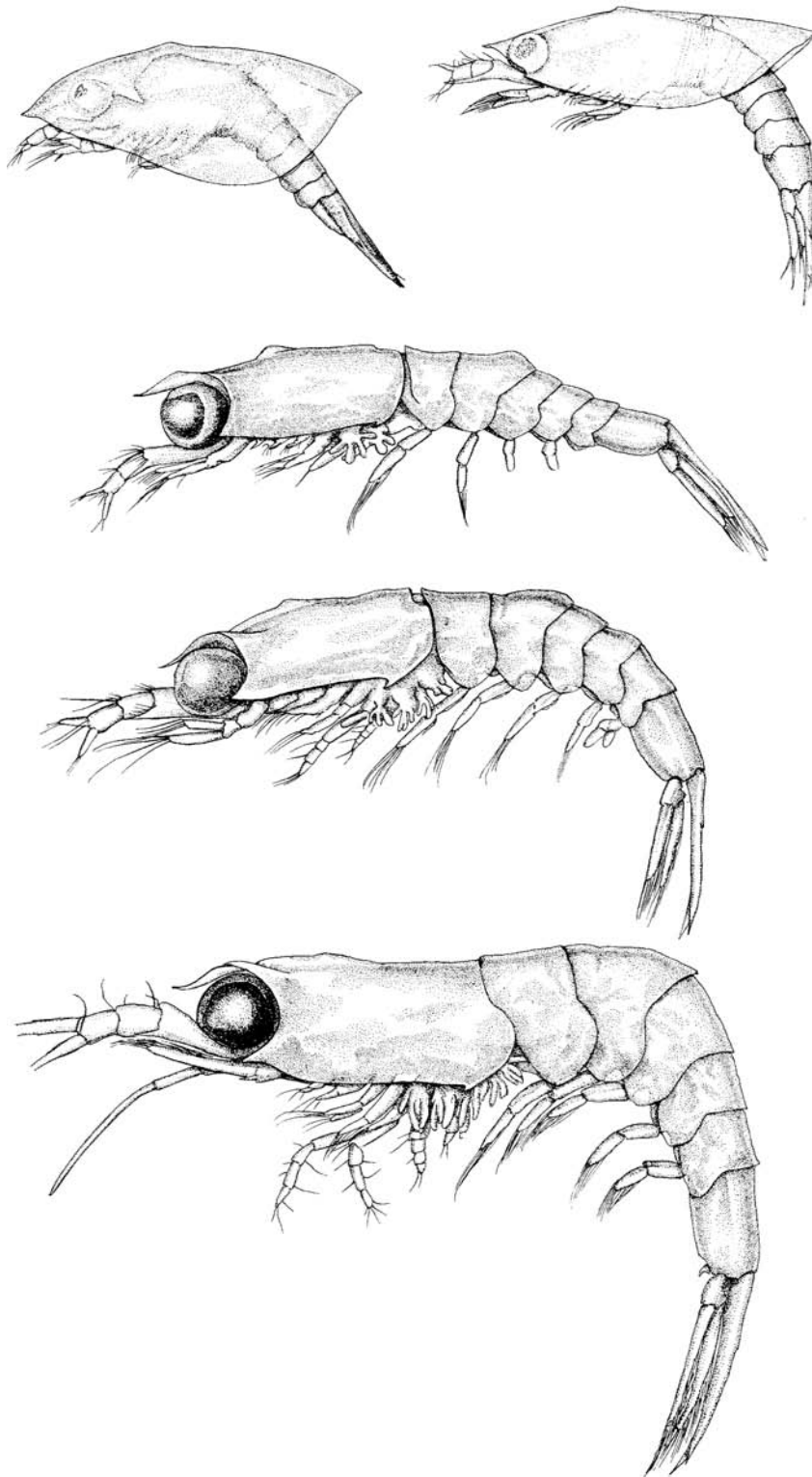
Figure 130. *Thysanopoda monacantha* larvae and juveniles. Calyptopis stages (2.9 and 3.4 mm), furcilia stages (4.5 and 5.0 mm), juvenile (6.4 mm), from South China Sea.

Thysanopoda aequalis. Fig. 131.

T. aequalis, Lebour, 1926b: 768-770, fig. 2. Small drawings show pleopod succession (0, 2′, 2″2′, 4″1, 5″) and median telson spine succession (7, 5, 3, 3?, 1) for the furcilia stages. The broad rostral plate and the form of the eye indicate that this is indeed *T. aequalis-astylata.*

T. aequalis, Lebour, 1949: 829, fig. 8, 1-2. A 3.8 mm furcilia III is depicted to show regions of coloration. Pleopod variants of 1′ and 2″3′ are mentioned.

T. aequalis-subaequalis, Casanova, 1974: 47, 54-61, figs. 7-9. Three calyptopis, three furcilia, and a post-larval stage are figured in dorsal and ventral views, also showing development of eye, head, thoracic appendages and telson spines. Ranges of size and modes provided for each stage. Pleopod development for Furcilia I given as 0 or 2′, for Furcilia II as 2″2′ or 4″1′, for Furcilia III as 5″.

Thysanopoda aequalis? species A, Gurney, 1947: 53-54, fig. 3. The broad rostral plate and the eye structure indicate that this furcilia is *T. aequalis-astylata.* A "Species B" was considered more likely by Gurney to be *aequalis*, but those specimens were larger, with a relatively narrow rostral plate.

The specimens described by Lebour, Casanova, and Gurney were from the Atlantic where *T. aequalis*, and not *T. astylata*, is known to occur. I therefore refer them to *T. aequalis.* The specimens illustrated in Fig. 131 conform to known stages.

Pseudeuphausia latifrons

Hansen, 1912: 290-291, plate 12, figs. 4a, 4b. Dorsal views and description of 3.2 mm specimen used to distinguish young stages of *Pseudeuphausia* from those of *Nyctiphanes.*

Tattersall, 1936b: 168-174, figs. 10-14. Full body of a calyptopis and a furcilia are figured, with sequential development of 1st and 2nd antennae and telson through furcilia stages. Calyptopis has ovoid carapace with evenly arched and smooth anterior margin; no lateral denticle. Furcilia has frontal plate deeply emarginate (in dorsal view), angular in the middle, the anterior projections being spine-like. The front margin of frontal plate becomes less cleft, more truncate, in juvenile and adult; the carapace develops a small lateral denticle.

Gurney, 1947: 54-56, figs. 3, 4. Using Tattersall's material, pleopod succession is shown to exhibit great individual variation.

The Great Barrier Reef material examined by Tattersall and Gurney was apparently insufficient in quantity to show any dominant path of pleopod succession. *Pseudeuphausia sinica* was found, however, to be dominated by two paths: 0, 3′, 3″2′, 5″ and 0, 4′, 4″1′, 5″ (Wang, 1965). No 4′ stage was observed in P. latifrons. Development in the two species appeared similar, though the exopod of the first maxilla is retained throughout life in *P. sinica.*

131
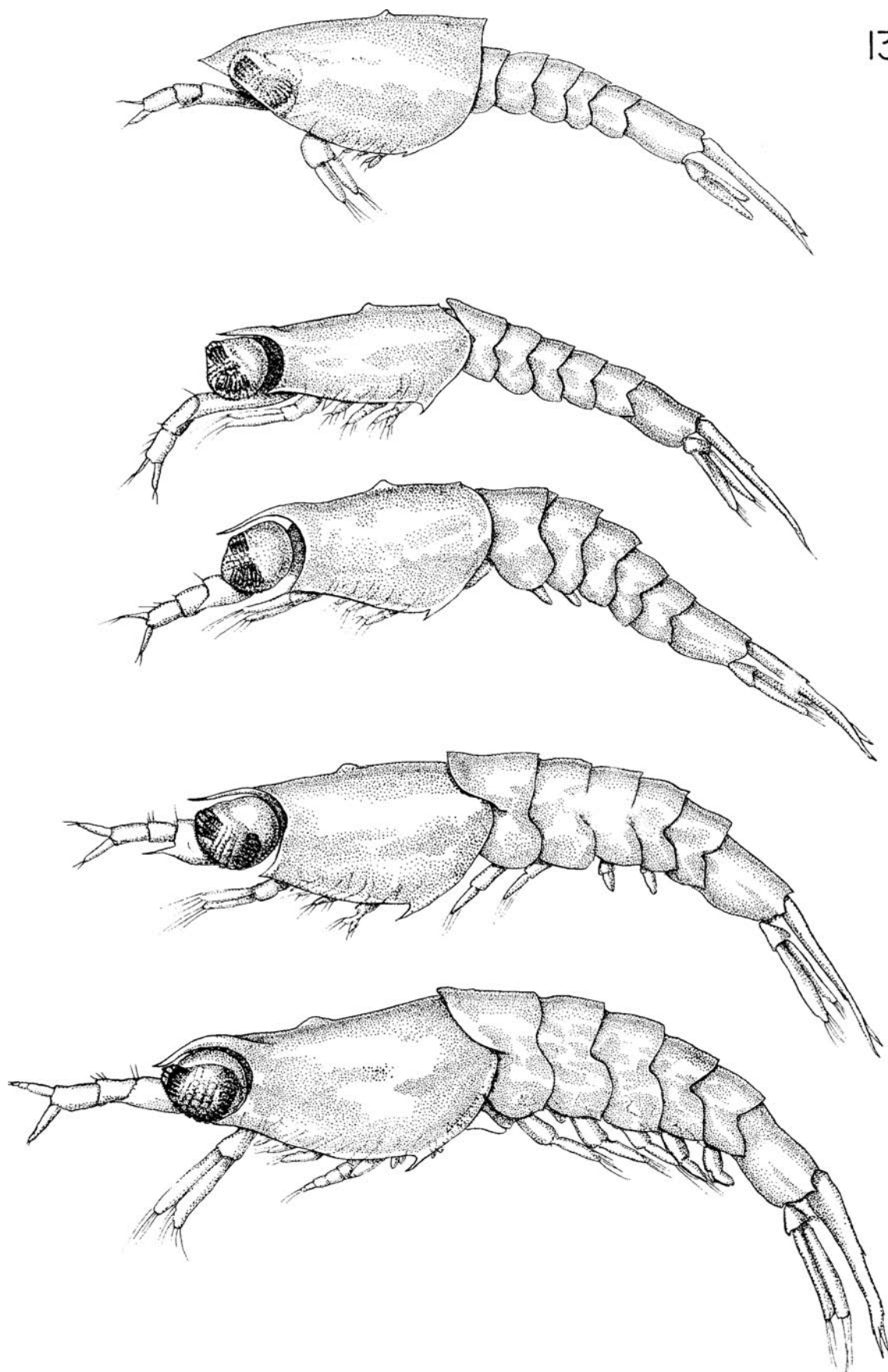
Figure 131. *Thysanopoda aequalis* larvae. Calyptopis stage (2.2 mm) and furcilia stages (2.4, 2.8, 2.9 and 3.3 mm), from South China Sea.

Euphausia recurva, E. mutica

> *E. recurva*, Talbot (1974). Metanauplius, calyptopis, and furcilia phases are described and illustrated (all stages in dorsal and lateral views). The identification of the series is tentative, but the specimens appear almost certainly to be *E. recurva. (Euphausia mutica* was considered a possibility.) Calyptopis stages and furcilia I possess the prominent dorsal-posterior spine on carapace. Anterior margin of carapace is serrate through part of furcilia phase. Pleopod succession is 1′, 1″4′, 5″.

These larvae resemble those of *Euphausia diomedeae* (Ponomareva, 1969). *E. recurva* appears not to reproduce in Southeast Asian waters. Larvae attributed to *Euphausia recurva* by Sheard (1953) have a smooth anterior margin to the carapace throughout and must be a different species, as Talbot pointed out, unrelated to the *recurva-mutica-diomedeae-brevis* complex in Hansen's "Group A".

Euphausia mutica larvae have not been isolated from those of the above complex. Reproductive adults appear not to be present in the South China Sea, but occur to the east of the Philippines and to the west of Australia as far north as 12°S.

Euphausia brevis

> Gurney, 1942: 168-172, Figs. 48, 49. Most larval stages are figured in considerable detail: two nauplii, metanauplius, two calyptopis stages, and the first furcilia. The rostral plate is deeply serrate in the metanauplius, becoming finely serrate in the furcilia. The dorsal-posterior carapace spine is present through furcilia 1. The pleopod succession is given as 1′, 1″4′, 5″.

> Lebour, 1949: 830-832, Fig. 1. Three calyptopis and two furcilia stages figured in dorsal and lateral view. Pigmentation is illustrated.

> Casanova, 1974: 65-75, Figs. 11-15. Development of calyptopis and furcilia phases shown in considerable detail, particularly frontal plate, telson, and head and thoracic appendages.

This species does not reproduce in Southeast Asian waters, except to the east of Luzon in the Philippine Sea and to the west of Java in the Indian Ocean. The larvae are like *Euphausia diomedeae, E. mutica*, and *E recurva* in the pleopod succession and in the serrated (fringed) rostral plate. The eye of *E. brevis* is smaller, its pigmentation being well illustrated by Gurney. The furcilia in Gurney's Fig. 49f appears to be a different species, as Lebour (1949) noted, the eye being relatively large and the body pigmentation different.

Euphausia diomedeae. Fig. 132.

> Ponomareva, 1969: 81-84, fig. 1. Reared specimens of nauplius, metanauplius, calyptopis I and II, and furcilia stages are figured. As in *Euphausia recurva* (above), the post-naupliar carapace is serrate along the anterior margin and bears a strong dorsal-posterior projection or spine.

The South China Sea specimens show the furciliar pleopod succession of 1′, 1″4′, 5″. The eyes are as in *Euphausia recurva* and probably *E. mutica:* relatively large and somewhat dark as compared with *E. brevis.* The larvae of all of these species are relatively smaller than those of the "Euphausia gibboides group" and do not follow the latter's pleopod succession of 1′, 1″3′, 4″1′, 5″ (Knight, 1975).
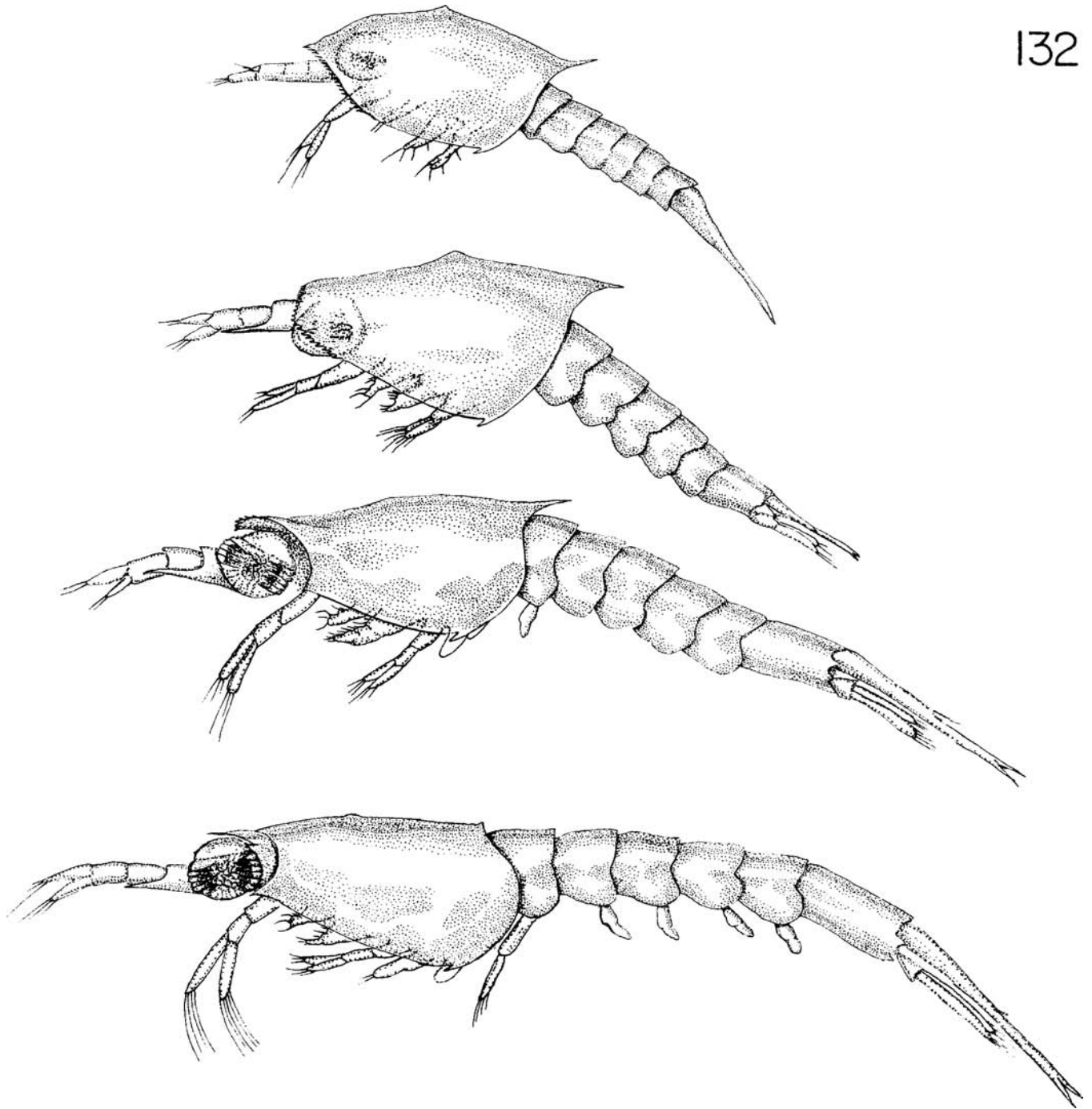
Figure 132. *Euphausia diomedeae* larvae. Calyptopis stages (1.6 and 2.2 mm) and furcilia stages (2.5 and 2.7 mm), from South China Sea.

Euphausia similis. Fig. 133.

> Sheard, 1953: 46. The size and pleopod succession of calyptopis and furcilia stages is given: calyptopis II, 1.7-1.8 mm; calyptopis III, 2.7-2.8 mm; furcilia with no pleopods, 2.5 mm; 1′ pleopod, 3.2-3.4 mm; 3′ pleopods, 3.3 mm; 1″3′ pleopods, 3.9 mm; 4″1′ pleopods, 3.5 mm; 5″ pleopods, 3-7 mm, as terminal telson spines are reduced from 7 to 1.

Sheard evidently recognized that these larvae have at the same time a smooth (unfringed) anterior margin to the carapace while possessing a strong dorsal-posterior carapace spine through furcilia I. This is indicated by his reference to a furcilia I larva figured by Tattersall (1924, Fig. 1), and tentatively assigned to *E. longirostris*, as almost certainly being *E. similis*, as John (1936) had earlier conjectured. The common pleopod succession is 1′, 1″3′, 4″1′, 5″.

Euphausia sanzoi, E. fallax

Larvae of the three species of the "Euphausia gibboides group" have recently been the object of rigorous study by Knight (1975, E. gibboides; in MS, *E. fallax, E. sanzoi).* These works are essential for identifying these larvae which have characteristics in common with larvae of the species in Hansen's Group "a" (e.g., *E. brevis, E. diomedeae, E. recurva),* such as serrated anterior margin of the carapace and conspicuous dorsal-posterior spine on the carapace during calyptopis stages and furcilia I. Among differences is the "E. gibboides group" pleopod succession of 1′, 1″3′, 4″1′, 5″ (cf. 1′, 1″4, 5″ in *E. diomedeae)* and their larger size.

Euphausia sibogae

Young of this species from south Asian waters have not been figured as yet. However, Hansen's description of a "last furcilia stage" of *E. distinguenda* from the eastern Pacific (1912: 287-288, plate 12, fig. 2) is relevant. The specimen is 2.8 mm; pleopods, 4″1′; telson spines, 3. It possesses a slender body, a high and anteriorly steep dorsal keel on the carapace and rather long eyestalks. The conspicuous keel and the very black eyes (smaller than those of *P. latifrons*) serve also to distinguish the young of *E. sibogae* (which, however, are undoubtedly very much like the young of *E. distinguenda)*. The larval rostral plate is short, barely acute, and without serrations.

133
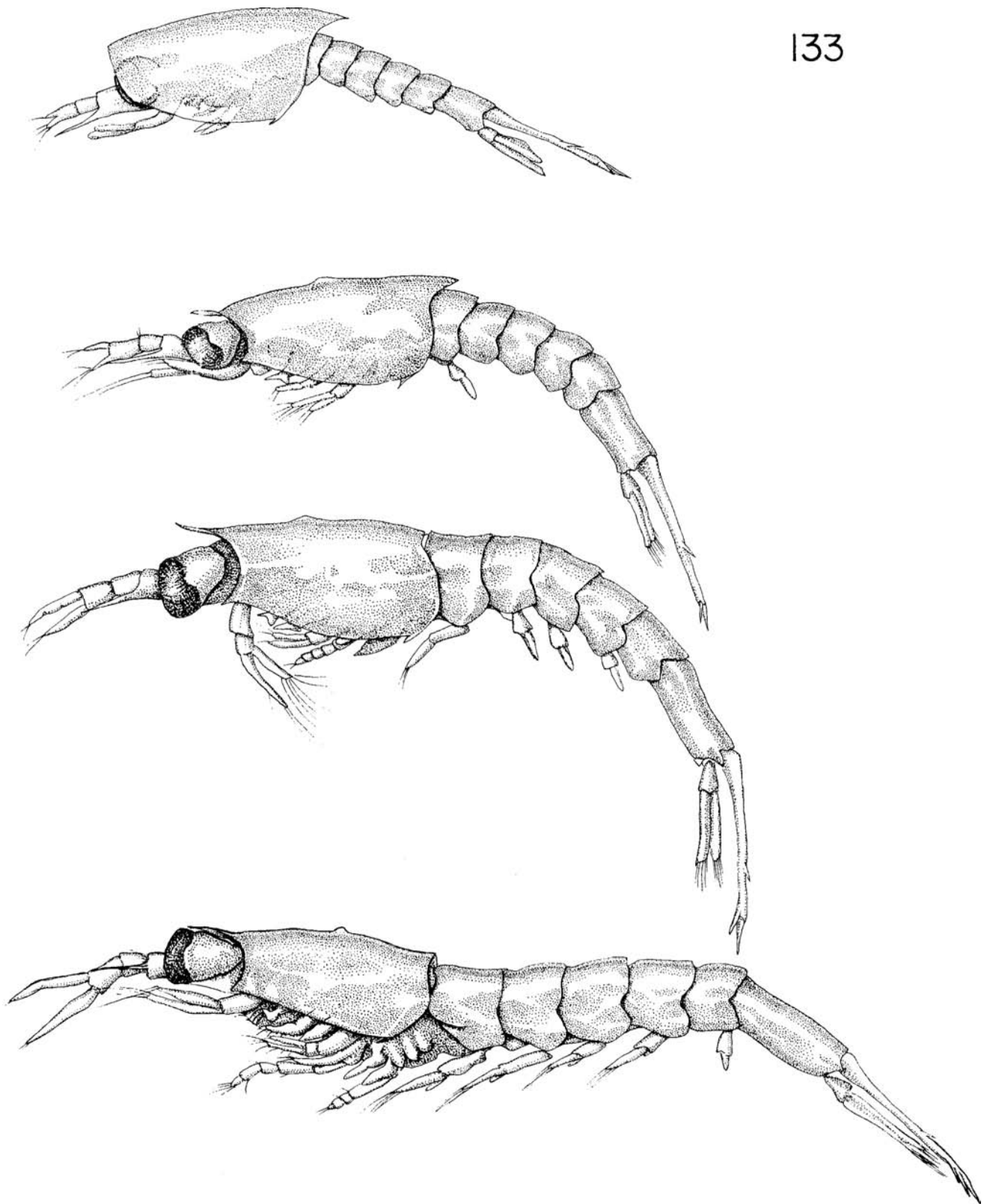
Figure 133. *Euphausia similis* larvae. Calyptopis stage (3.0 mm) and furcilia stages (3.9, 4.6 and 5.3 mm), from East China Sea.

Euphausia hemigibba

Lebour, 1949: 822, fig. 4, 1-2. A 3.5 mm 1st furcilia (pleopods: 1′) is tentatively attributed to *E. hemigibba* and a 5.6 mm post-larva is definite, the eye characteristics being well illustrated.

Casanova, 1974: 77-83, figs. 16-18. Anterior margin of carapace shown to be smooth (without serrations) becoming pointed in furcilia III. There is no middorsal posterior spine on the carapace. Pleopod succession is 1′, 1″4′, 5′.

The above records are from regions (Bermuda, Mediterranean) where, of the "E. gibba group" species, only *E. hemigibba* is known, hence their identity is almost certain.

Euphausia pseudogibba. Fig. 134.

A calyptopis and two furcilia stages are figured. These specimens are from the South China Sea where, of the "E. gibba group" species, apparently only *pseudogibba* reproduces. The pleopod succession is like that of *E. hemigibba.*

Larvae of the "E. gibba group" are distinguished by 1) smooth anterior margin of carapace, 2) absence of middorsal-posterior carapace spine, 3) small eye, with facets of upper portion of eye forming *broader* area than in lower portion of eye (contrasting with *E. tenera* which also has very small eyes).

Euphausia tenera. Fig. 135.

Lebour, 1949: 832, fig. 3, 2-11. Small larvae, with very small eyes. Anterior carapace margin not serrated (fringed), but rostral plate aquires median anterior tooth or point in Furcilia I. Pleopod succession is constant: 1′, 1″4′, 5″. Small illustrations provide dorsal, lateral, views, including rostrum and telson.

The South China Sea specimens agree with those from Bermuda. There is a small but conspicuous dorsal projection (keel) on the carapace. The small midportion of the eye remains almost black in preserved specimens. The lower faceted portion of the eye is broader than the upper, in contrast to species of the "Euphausia gibba group" (which also have very small eyes) in which the upper portion of the eye is broader.

Specimens from the Benguela Current considered to be *E. tenera* by Boden (1955) appear to be too large for that species (e.g. the 4″1′ stage is 4.9 mm as compared with 3.0 mm for our specimens of that stage). Further, the pleopod succession given as 1″3′, 4″1′, 5″ differs.

134
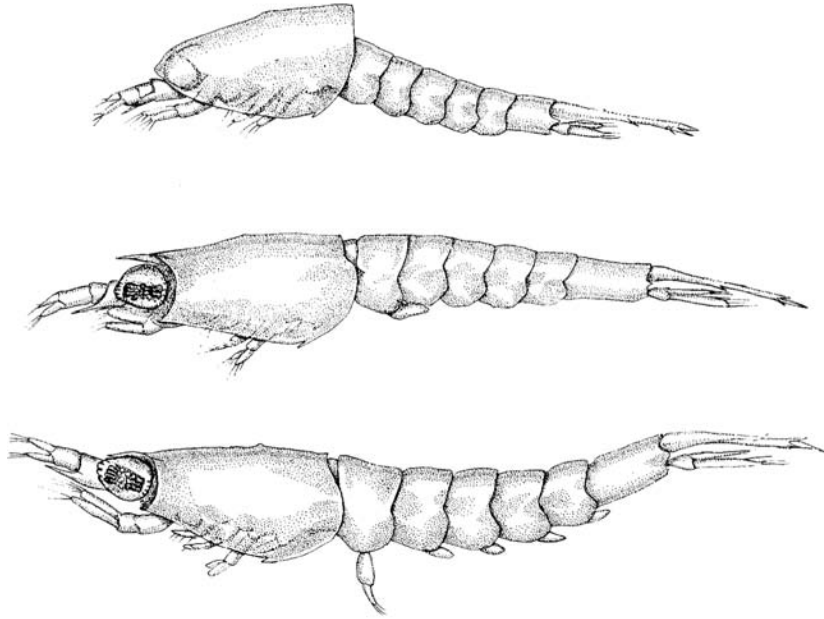
Figure 134. *Euphausia pseudogibba* larvae. Calyptopis stage (2.4 mm) and furcilia stages (3.1 and 3.4 mm), from South China Sea.

135
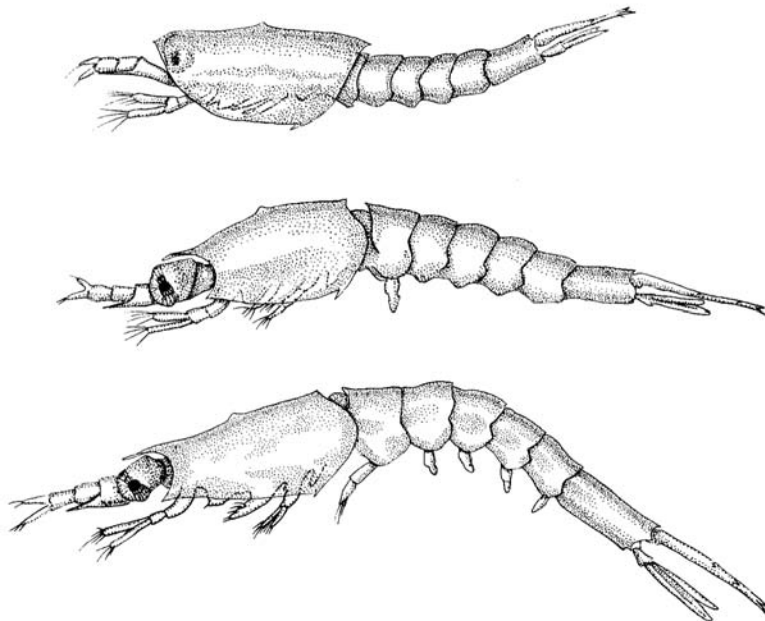
Figure 135. *Euphausia tenera* larvae. Calyptopis stage (1.8 mm) and furcilia stages (2.6 and 3.0 mm) from South China Sea.

Genus Nematoscelis

The larvae of the tropical-subtropical Nematoscelis species are, for the most part, unreliably known. Hence, published descriptions must be used with reserve. In particular, larvae of the *N. microps-N. atlantia-N. gracilis* complex have proven difficult to sort. N. tenella, the furcilia of which possess a particularly high and long carapace keel, a downward-curving rostrum, and a short sixth abdominal segment, is relatively distinctive. All four of these species show pleopod succession of 1′, 1″3′, 4″1′, 5″, as compared with 2′, 2″3′, 5″ in the temperate species N. *megalops* and *N. difficilis* (Gopalakrishnan, 1973a, 1973b).

For the identification of furcilia larvae, the reader is referred to a key devised by Gopalakrishnan (1973b) which separates the tropical-subtropical species on the basis of the shape of the frontal plate, rostrum and carapace keel.

Of these species, only *N. atlantica* is known from the Mediterranean Sea (Ruud, 1936). The larval series described under *N. atlantica-N. microps* (Casanova-Soulier, 1968; Casanova, 1974) appear, therefore, to be of N. atlantica. The larvae listed as *N. microps* by Lebour (1926b) from the Mediterranean must also be *N. atlantica.*

Specimens described by Sars (1885, N. rostrata), Hansen (1912, *N. microps*), and Lebour (1949, *N. microps*) are from areas where either *N. atlantica* or *N. gracilis occurred* in addition to *N. microps* and are therefore useful only in a general way. Lebour's *N. tenella* larvae (1949, Fig. 5, 6-13) appear likely to be that species, judging from the narrow elongate eye in the furcilia stages.

Genus *Stylocheiron*

Larvae of many of these species are common inhabitants of the near-surface waters of tropical-subtropical seas. A series representative of each of the three lineages in the genus (see taxonomic discussion) is illustrated here: *Stylocheiron carinatum*, S. affine (larvae of geographical forms not distinguished) and S. abbreviatum. The pleopod succession common to the genus, with rare individual deviations, is 1′, 1″2′, 3″2′, 5″.

Larvae of six *Stylocheiron* species which are common to the three low-latitude oceans have been recognized and reported upon in the literature based on Atlantic specimens. Larvae of the Indo-Pacific endemic species S. microphthalma, S. indicus, and *S. insulare* and of the sparsely occurring, more broadly ranging *S. robustum* are not yet described.

Stylocheiron carinatum. Fig. 136.

> Hansen, 1912: 293-294, plate 12, fig. 6a-d. A furcilia (pleopods, 1″2′, 2.8 mm in length) is figured in lateral and dorsal view, and a "last furcilia", 3 mm, in lateral head view. Distal setae on elongate 3rd leg confirm diagnosis. Lack of lateral carapace denticle during furcilia phase is generic character.

> Lebour, 1949: 825-826, fig. 1, 1-4. Nauplii and metanauplius, obtained after hatching eggs, are figured and described.

> Lewis, 1955: 191-194, figs. 1, 2. Three calyptopis and two furcilia stages are figured, including telson spines. Development of large eye, with darkened lower-central portion, is diagrammed. Calyptopis stages are 1.75-2.59 mm in length. Furcilia I (no pleopods), 2.65 mm; furcilia II (pleopod 1′), 2.70 mm.
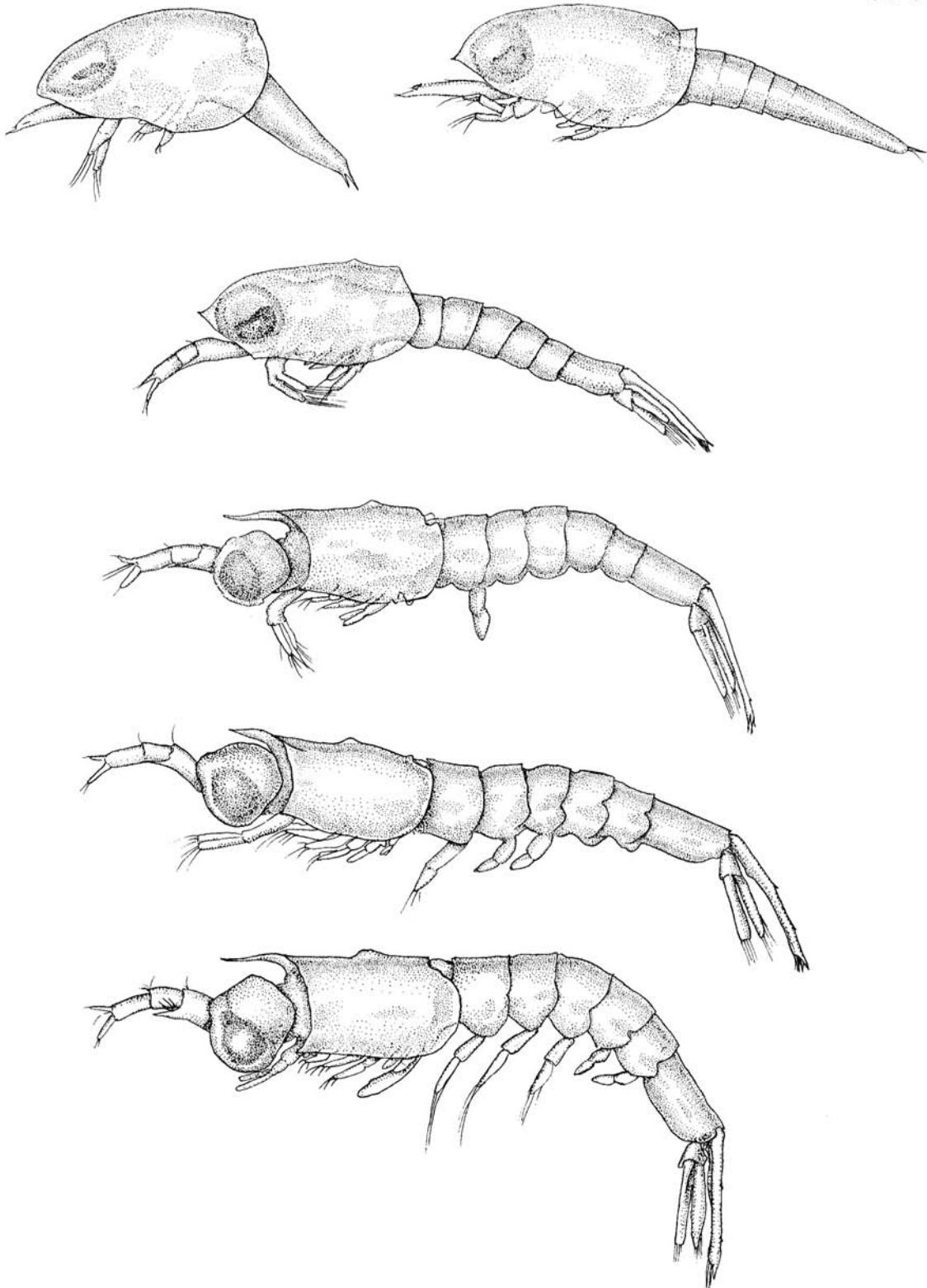
Figure 136. *Stylocheiron carinatum* larvae. Calyptopis stages (1.6, 1.8 and 2.1 mm) and furcilia stages (2.8, 3.0 and 3.3 mm), from South China Sea.

Ponomareva, 1969: 84–85, fig. 3. Nauplius (heart-shaped rather than ovoid), metanauplius, calyptopis and early furcilia stages hatched from eggs are illustrated. A furcilia (pleopods 1″ 2′) has eye divided into two parts. The ommatidia of the upper part are longer than those of the lower.

Stylocheiron suhmii

Lebour, 1926a: 203–211, figs. 1, 2. Eye of furcilia described as of two parts, narrow upper-anterior portion usually with two, sometimes three, cones in transverse row, noted to be similar to adult eye. Pleopod succession interpreted as 0 (2.2 mm), 1′, 2′, 1″2′, 2″3′, 3″2′, 5″ (2.8 mm), inasmuch as all these stages were observed. Terminal telson spines found to be six in all stages until pleopods 5″ were attained, when spines reduced to four. Subsequent cyrtopia stages had a single terminal spine. Third thoracic leg remains small through furcilia phase. Dorsal and lateral views of furcilia stages and of telson spination are provided.

Lebour, 1926b: 773–774, fig. 4 p-s. Three calyptopis stages are figured. The first two measure 1.28 and 1.76 mm and have six terminal telson spines. The third specimen (broken) shows first rudiments of anterior lenses of eye.

Lebour, 1949: 824. Usual pleopod succession described as 0, 1′, 1″2′, 3″2′, 5″, with variants of 2″3′ and 1″. Body is colorless or pinkish, with red photophores.

Casanova, 1974: 111–118, figs. 28-30. All furcilia stages and a post-larva are figured. Characteristics of stages are as follows: calyptopis I, 1.2 mm; calyptopis II, 1.7 mm; calyptopis III 2.0–2.5 mm; furcilia I (0 or 0′) 2.4–2.5 mm; furcilia II (1″2′ or 3″2′) 2.6–3.0 mm; furcilia III (5″) 2.8–3.3 mm, with 6, 4, or 1 terminal telson spines.

The eye of the furcilia of this species generally shows two facets in the distal transverse row, as compared with three in the adult. Furcilia of *S. affine* usually showed three facets in the distal row, as compared with four or more in the adult.

Stylocheiron affine. Fig. 137.

S. affine larvae have not been described. The series shown here consists of a late calyptopis and four furcilia, omitting the stage with pleopods 3″2′. Ommatidia in the upper portion of the eye are differentiated as early as the last calyptopis. Through the furcilia phase there are no more than three ommatidia in the distal transverse row, agreeing with the diagnosis of adult *S. suhmii*, with which species these larvae may be confused.

Stylocheiron elongatum

Lebour, 1949: 824. Body is described as colorless, eye has conspicuous red photophore on specimens of 4.5–6.0 mm.

Lewis, 1955: 194–197, figs. 3, 4. Calyptopis and furcilia (stages I and II, pleopods, 0 and 1′), identified on the basis of large size, are described and figured. Calyptopis stages range from 2.52–3.64 mm in length; the large eyes are developing and conspicuous. In furcilia I (3.92 mm) the elongate, cylindrical, central portion of the eye is diagnostic. In furcilia II (4.2 mm) the elongate eye becomes barely constricted, with distinct ommatidia showing at the anterior end.
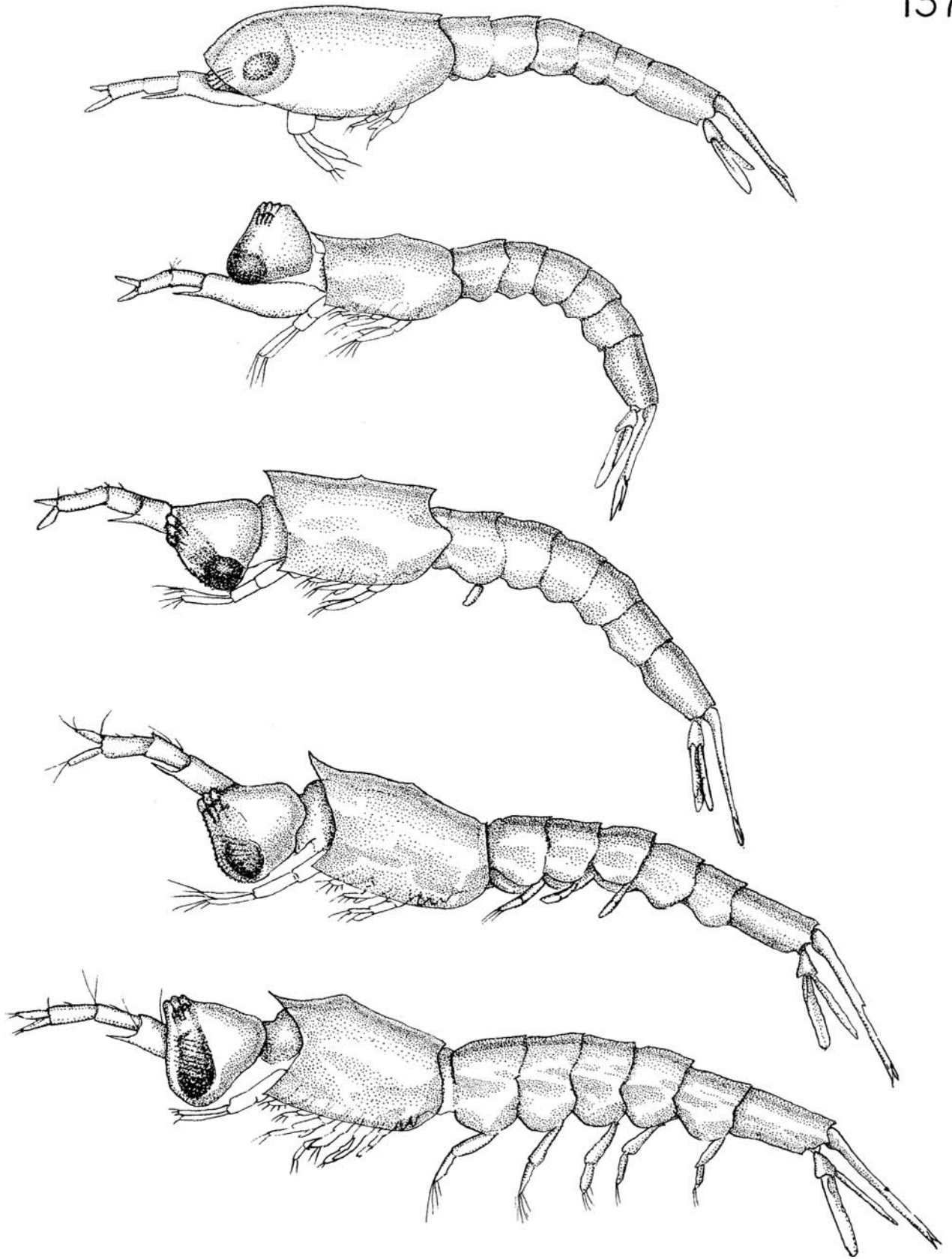
Figure 137. *Stylocheiron affine* larvae (Form undetermined). Calyptopis stage (2.2 mm) and furcilia stages (2.1, 2.8, 3.1 and 3.4 mm) from South China Sea.

Stylocheiron longicorne

Frost, 1935: 443–458, figs. Pleopod succession described as 0, 1′, 1″2′, 3″2′, 5″.

Casanova, 1974: 105–109, figs. 26-27. Calyptopis and furcilia stages, figured in various aspects, have characteristics as follows: calyptopis I, 1.3 mm; calyptopis II, 1.7–1.9 mm; calyptopis III, 2.3–2.4 mm; furcilia I without pleopod (1.9–2.4 mm) or with 1′ pleopod (2.5–2.9 mm); furcilia II, 1″2′ (2.7–2.9 mm) or 3″2′ (3.0–3.5 mm); furcilia III, 7, 5 or 1 terminal telson spines, 3.0–3.6 mm. Eye shown as relatively cylindrical through furcilia phase, with 3 or 4 facets in distal transverse row.

Stylocheiron abbreviatum. Fig. 138.

Lebour, 1926a: 203–211, fig. 3. Three furcilia (pleopods: 1″2′, 3.2 mm in length, seven terminal telson spines; 3″2′, seven spines; 5″, 3 mm in length, five spines) are illustrated. Carapace described as extremely short, strongly carinate anteriorly and humped near center, with long pointed rostrum in all stages.

Lebour, 1949: 826–828, fig. 1, 9-12. Normal pleopod succession confirmed as 0, 1′, 1″2′, 3″2′, 5″, with variant of 2″3′. Figures depicting furcilia show regions of coloration characteristic of the species.

Einarsson, 1945: 14. Agrees with pleopod succession given by Lebour.

Lewis, 1955: 199–201, figs. 6, 7. Three calyptopis and two furcilia stages, figured in dorsal and lateral view, have characteristics as follows: calyptopis I, 2.24 mm; calyptopis II, 2.66 mm with six terminal telson spines as in stage I; calyptopis III, 2.87 mm, seven telson spines, lower part of eye now darkened; furcilia I, 2.94 mm, telson unchanged, no pleopods, eye with numerous ommatida showing; furcilia II, 3 mm, 1′ pleopod, seven telson spines, eye much enlarged.

Casanova, 1974: 119–131, figs. 31-36. Calyptopis and furcilia stages figured in various aspects, and compared stage-by-stage with *S. maximum*. There is general agreement with lengths given by Lewis for calyptopis stages and furcilia I (no pleopods). Stage with one non-setose pleopod considered also to be furcilia I; furcilia II, 1″2′ or 3″2′, 3.3–3.85 mm; furcilia III, 5″, with five telson spines (3.3–3.57 mm) or one telson spine (3.3–4.9 mm). Comparable stages of *S. maximum* are roughly one-third again as large as *S. abbreviatum*.
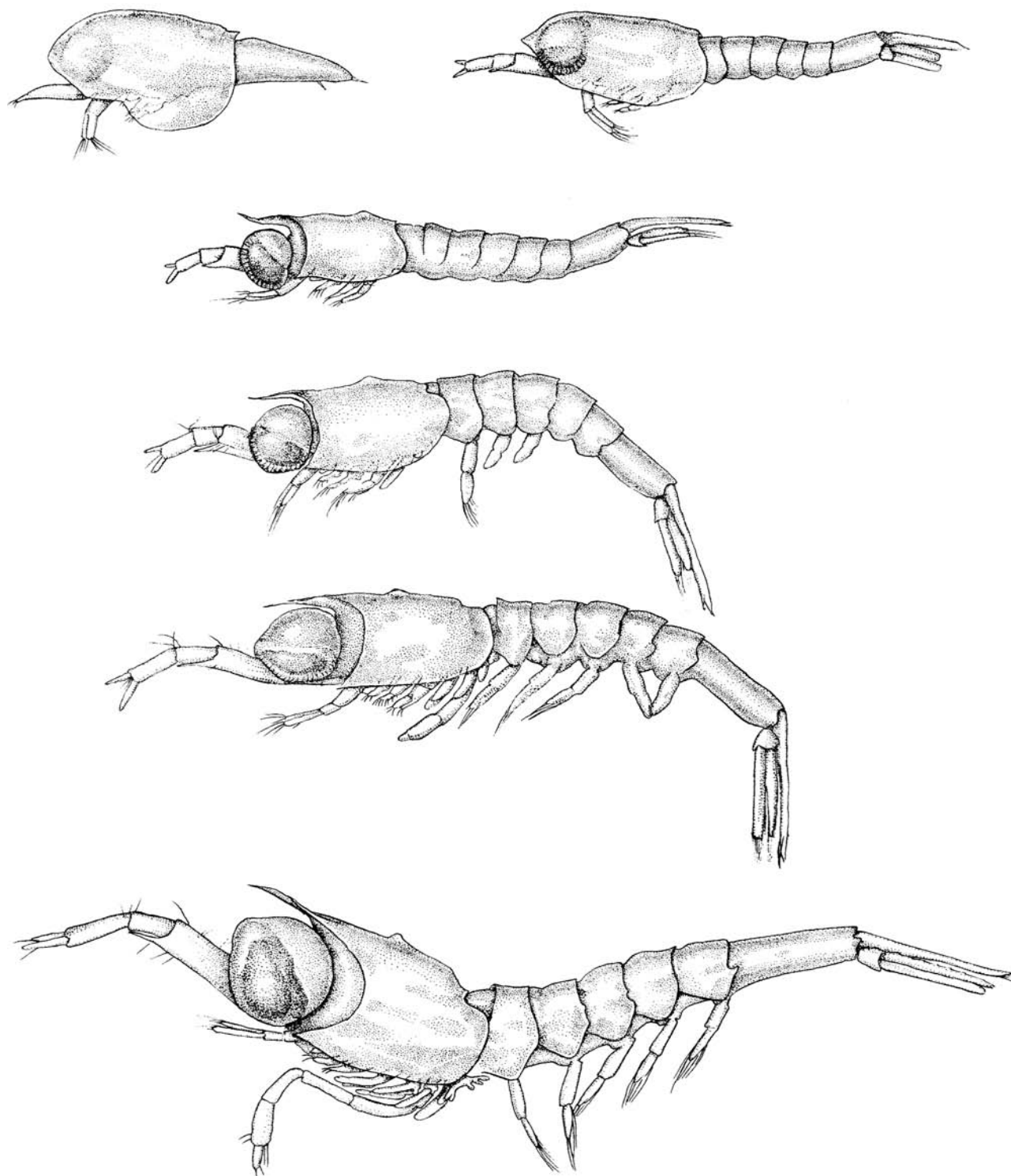
Figure 138. *Stylocheiron abbreviatum* larvae. Calyptopis stages (1.8, 2.6) and furcilia stages (2.8, 3.2, 3.9 and 4.4 mm) from South China Sea.

Stylocheiron maximum

Lewis, 1955: 197–198, fig. 5. A calyptopis and a furcilia stage are figured and described: calyptopis II, 3.92 mm, telson with six terminal spines, carapace equal in length to uncovered part of abdomen; furcilia II, 4 mm, 1′ pleopod, telson with seven terminal spines, eye-stalks very long, eyes large and heavily pigmented.

Casanova, 1974: 119–131, figs. 31-36. Calyptopis and furcilia stages are figured in various aspects and compared with the same stages of the smaller species *S. abbreviatum*. Calyptopis I, 2.47–2.70 mm, telson with six terminal spines; calyptopis II not found; calyptopis III, 3.85 mm, telson with seven terminal spines, eye much more developed than in *S. abbreviatum*; furcilia I, 3.6–4.4 mm, telson with six terminal spines, 0 or 1′ pleopod; furcilia II, 4.0–4.4 mm, telson with six or seven terminal spines and 1″2′ pleopods, or 3″2′ (4.40–4.95 mm); furcilia III 4.80–5.22 mm and telson with five terminal spines, or 5.22–5.70 mm and telson with one terminal spine, 5″ pleopods in both cases.

Stylocheiron sp. ?, Gurney, 1947: 63–64, fig. 8. A stalk-eyed larva is figured and described, eye and eye-stalk together being about one-fifth of total body length. Specimens observed with pleopods 0, 1′, 2′, 3′, but normal succession judged to be 0, 1′, 1″2′, 3″2, 5″. Specimen with 3′ shown with five terminal telson spines. Body lengths not given. *S. maximum* mentioned as a possibility.

Stalk-eyed euphausiid, Lebour, 1949: 828, fig. 1, 11-12. Specimens observed with pleopods 0, 1′, 1″2′, 3″2′ and a single specimen with 2″3′. Length of these specimens is 2.2–4.2 mm.

Lebour's specimens were somewhat smaller than those listed by Lewis and Casanova, particularly the furcilia I with 0 pleopods. In view of the probable presence of *Stylocheiron robustum* (larvae not described) in the Bermuda area, the identity of many of the above larvae is in doubt. *S. robustum*, however, is not known from the Mediterranean where Casanova worked.

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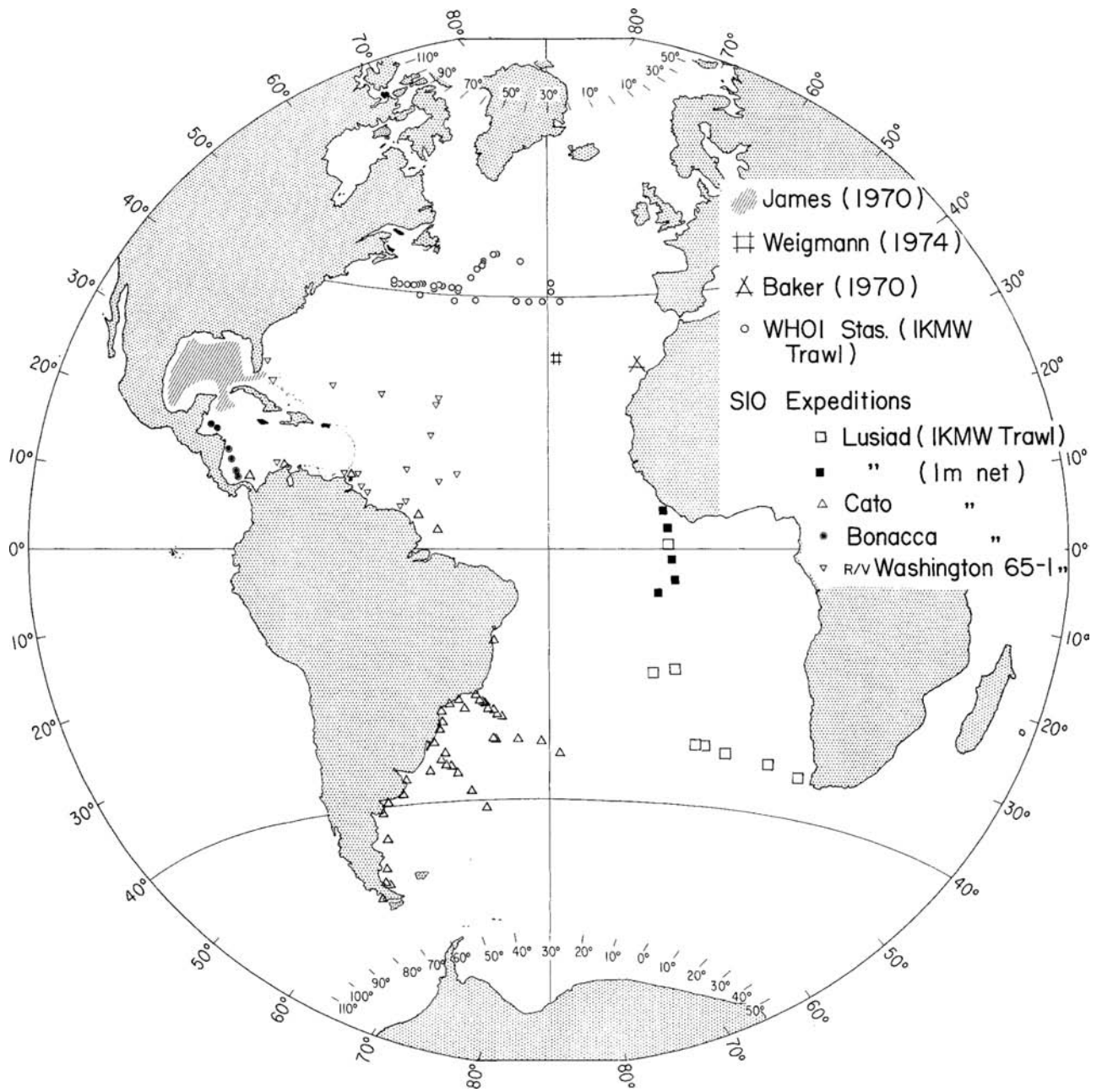
Appendix I. Figure 139. Localities supplementing those illustrated in Mauchline and Fisher (1969), used in determining the species distributions shown for the Atlantic Ocean.

APPENDIX II

DATA PLOTTED IN FIGURES 8, 20, 21 (GRAPHS OF SEASONAL ABUNDANCES OF SPECIES, BY CRUISE)
WITH STANDARD DEVIATIONS, RANGES OF VALUES

CRUISE		X	S.D.	RANGE	SPECIES PRESENT	STAGE PRESENT	X	S.D.	RANGE	SPECIES PRESENT	STAGE PRESENT
					NO. OF STATIONS					NO. OF STATIONS	
		Stylocheiron carinatum					*Euphausia diomedeae*				
S- 2	Adlt.	39.0	63.9	0-235	17	12	7.5	11.4	0-32	13	6
	Juv.	195.0	228.3	0-790		15	27.3	37.8	0-106		6
	Larv.	38.5	55.9	0-198		11	58.8	50.9	0-172		12
S- 4	A.	78.8	121.8	0-610	32	26	50.0	147.3	0-725	24	13
	J.	230.6	255.7	0-978		31	24.5	71.8	0-347		10
	L.	114.0	128.8	0-432		28	130.3	142.6	0-497		23
S- 6	A.	123.9	166.5	0-745	30	26	51.1	82.5	0-329	23	11
	J.	129.8	104.5	0-393		29	77.3	203.3	0-974		12
	L.	58.9	54.7	0-183		26	253.9	328.5	0-1365		22
S- 8	A.	75.5	128.8	0-599	35	28	42.0	70.9	0-286	22	14
	J.	125.4	121.4	2-507		35	54.9	72.9	0-241		14
	L.	37.7	34.9	0-131		27	146.7	187.6	2-676		22
S-10	A.	100.6	117.5	2-525	22	22	14.5	19.5	0-77	18	10
	J.	205.1	173.8	18-628		22	9.8	11.0	0-24		10
	L.	80.3	71.8	0-326		21	71.8	60.9	5-219		18
		Stylocheiron microphthalma					*Euphausia sanzoi*				
S- 2	A.	13.3	17.6	0-61	13	9	0.0	0.0	0	4	0
	J.	10.9	16.4	0-41		5	13.3	17.7	0-38		3
	L.	4.2	9.5	0-30		3	0.8	0.9	0-2		2
S- 4	A.	22.2	23.7	0-94	31	22	0.0	0.0	0	8	0
	J.	10.1	17.0	0-62		11	126.3	298.8	0-855		6
	L.	30.3	29.5	0-105		24	13.6	25.0	0-62		3
S- 6	A.	25.6	18.5	0-69	28	27	1.9	6.7	0-25	14	2
	J.	12.5	18.4	0-65		13	14.3	26.7	0-75		8
	L.	15.3	20.9	0-77		20	52.4	130.1	0-451		7
S- 8	A.	10.8	13.2	0-53	28	21	0.3	0.7	0-2	13	2
	J.	8.6	12.8	0-53		16	117.7	252.1	0-865		12
	L.	13.8	23.3	0-110		18	49.7	166.8	0-604		5
S-10	A.	22.7	25.9	0-97	23	17	0.0	0.0	0	15	0
	J.	15.5	18.3	0-71		16	5.1	7.6	0-24		9
	L.	22.2	18.1	0-77		20	83.1	281.9	0-1101		9
		Stylocheiron affine (3 forms combined)					*Euphausia tenera*				
S- 2	A.	10.1	20.1	0-59	11	5	32.8	59.8	0-192	17	5
	J.	16.1	18.5	0-63		8	105.8	180.1	0-562		14
	L.	20.0	22.1	0-71		9	80.9	259.7	0-1075		6
S- 4	A.	14.9	18.0	0-77	28	19	29.5	47.4	0-147	29	11
	J.	32.5	45.2	0-225		25	53.7	96.8	0-347		14
	L.	41.4	54.9	0-228		23	60.9	57.6	0-225		26
S-6	A.	19.5	22.1	0-83	28	23	30.7	42.3	0-156	22	11
	J.	38.0	40.1	0-153		25	56.5	60.0	0-246		20
	L.	8.6	11.1	0-38		15	26.7	20.2	0-70		20
S- 8	A.	25.2	25.4	0-88	29	28	33.6	46.1	0-163	20	12
	J.	52.2	59.8	0-258		27	53.4	67.8	0-275		18
	L.	19.3	23.4	0-117		23	34.8	66.2	0-286		13
S-10	A.	16.6	9.8	6-41	18	18	26.5	36.2	0-127	24	14
	J.	26.2	21.4	0-78		15	47.3	40.9	0-163		23
	L.	20.5	24.5	0-77		13	33.1	26.9	0-113		23

CRUISE		X	S.D.	RANGE	NO. OF STATIONS SPECIES PRESENT	STAGE PRESENT	X	S.D.	RANGE	NO. OF STATIONS SPECIES PRESENT	STAGE PRESENT
		Stylocheiron longicorne					*Euphausia pseudogibba*				
S- 2	Adlt.	3.9	4.1	0-10	7	4	5.3	6.7	0-18	6	4
	Juv.	10.6	18.0	0-50		5	8.8	8.6	0-18		3
	Larv.	2.9	5.9	0-16		2	2.8	6.0	0-2		1
S- 4	A.	2.3	7.8	0-33	19	2	6.8	13.1	0-49	15	6
	J.	10.9	21.8	0-75		6	11.8	11.9	0-34		10
	L.	21.5	20.8	0-74		18	5.1	15.2	0-59		3
S- 6	A.	1.1	2.3	0-8	23	6	9.2	22.5	0-95	18	8
	J.	8.1	8.6	0-30		16	9.9	15.5	0-45		7
	L.	11.5	8.7	0-29		21	16.6	13.9	0-48		14
S- 8	A.	4.8	9.3	0-42	23	10	9.2	18.8	0-74	17	7
	J.	22.9	18.9	0-66		20	13.5	26.7	0-110		11
	L.	21.5	23.3	0-102		19	20.3	27.9	0-98		14
S-10	A.	0.6	1.6	0-6	16	2	2.6	4.3	0-13	18	7
	J.	6.6	7.1	0-24		11	3.8	6.7	0-24		6
	L.	15.3	10.9	0-34		13	17.6	17.7	0-79		16
		Stylocheiron suhmii					*Euphausia mutica*				
S- 2	Total	20.0	0.0	0	1	1	2.0	0.0	0	1	1
S- 4	T.	3.4	2.1	2-8	10	10	12.7	24.2	2-62	6	6
S- 6	T.	4.7	3.4	2-11	15	15	0.0	0.0	0	0	0
S- 8	T.	3.3	3.3	2-10	6	6	2.0	0.0	2-2	2	2
S-10	T.	5.8	4.5	2-12	4	4	2.0	0.0	0	1	1
		Nematoscelis gracilis					*Thysanopoda tricuspidata*				
S- 2	A.	2.6	8.4	0-35	17	5	0.1	0.5	0-2	19	1
	J.	17.6	28.4	0-112		15	7.3	20.7	0-91		8
	L.	18.3	34.4	0-122		9	35.1	67.2	0-292		17
S- 4	A.	5.1	9.2	0-45	29	14	0.7	1.7	0-6	29	5
	J.	48.4	80.9	0-315		25	37.1	175.4	0-948		14
	L.	49.3	46.9	0-196		26	32.7	69.0	0-372		25
S- 6	A.	7.9	17.1	0-23	24	12	0.4	1.1	0-4	18	3
	J.	69.3	81.1	6-286		24	13.5	19.1	0-78		12
	L.	21.4	21.1	0-72		17	33.9	36.8	0-120		16
S- 8	A.	2.8	5.6	0-21	24	7	0.0	0.0	0	18	0
	J.	44.2	49.7	2-181		24	6.8	10.4	0-35		11
	L.	20.6	25.1	0-90		13	18.9	16.6	0-58		15
S-10	A.	4.5	7.6	0-30	22	8	0.6	1.8	0-6	20	2
	J.	22.4	12.9	2-54		22	7.7	10.3	0-32		13
	L.	13.5	15.9	0-60		15	19.1	11.9	0-39		19
		Stylocheiron maximum					*Thysanopoda pectinata*				
S- 2	Total	2.5	0.7	2-3	2	2	0.0	0.0	0	0	0
S- 4	T.	3.3	1.8	2-6	11	11	0.0	0.0	0	0	0
S- 6	T.	2.0	0.0	2-2	6	6	2.7	1.2	2-4	3	3
S- 8	T.	5.4	3.4	2-12	7	7	3.0	1.0	2-4	3	3
S-10	T.	6.0	6.1	2-18	6	6	3.3	2.5	1-6	3	3

CRUISE		X	S.D.	RANGE	NO. OF STATIONS SPECIES PRESENT	STAGE PRESENT		X	S.D.	RANGE	NO. OF STATIONS SPECIES PRESENT	STAGE PRESENT
		Nematoscelis microps							*Thysanopoda monacantha*			
S- 2	Adlt.	1.1	2.6	0-9	12	3		0.3	0.7	0-2	9	2
	Juv.	6.3	9.8	0-31		7		0.1	0.3	0-1		1
	Larv.	12.0	12.9	0-35		9		1.7	1.5	0-5		7
S- 4	A.	0.6	2.1	0-10	26	3		0.0	0.0	0	18	0
	J.	17.7	20.1	0-93		23		0.1	0.5	0-2		1
	L.	17.0	24.5	0-118		17		3.9	2.8	0-10		17
S- 6	A.	2.8	6.4	0-28	25	7		0.0	0.0	0	18	0
	J.	43.6	73.1	0-348		24		0.9	1.8	0-7		5
	L.	8.8	14.2	0-69		15		7.7	9.1	0-40		17
S- 8	A.	2.3	4.3	0-17	24	8		0.3	1.1	0-4	13	1
	J.	31.9	39.3	0-195		22		0.6	0.9	0-2		4
	L.	27.9	38.3	0-154		16		3.0	3.2	0-11		10
S-10	A.	1.2	2.2	0-6	20	6		0.1	0.2	0-1	17	1
	J.	19.3	19.2	0-66		16		0.7	1.8	0-6		3
	L.	29.4	36.7	0-114		16		14.7	11.5	2-42		17
		Nematoscelis tenella							*Thysanopoda aequalis*			
S- 2	A.	0.6	1.3	0-4	10	2		1.3	1.8	0-4	9	4
	J.	7.0	9.8	0-31		7		9.3	11.7	0-32		6
	L.	1.9	3.4	0-10		3		10.4	18.8	0-56		4
S- 4	A.	0.7	2.1	0-9	20	3		5.8	12.8	0-57	25	8
	J.	12.5	15.6	0-63		18		12.5	17.5	0-59		15
	L.	3.5	6.9	0-23		7		22.9	19.7	0-67		21
S- 6	A.	0.0	0.0	0	20	0		3.9	6.6	0-25	22	9
	J.	6.5	8.4	0-28		15		14.5	11.3	0-41		20
	L.	3.2	3.9	0-10		10		12.1	11.6	0-33		16
S- 8	A.	0.2	0.9	0-4	17	1		1.9	2.9	0-9	22	8
	J.	8.8	8.1	0-27		15		7.7	10.8	0-43		14
	L.	10.1	14.6	0-50		8		8.7	13.9	0-49		16
S-10	A.	0.5	1.5	0-6	16	2		6.6	12.1	0-49	22	9
	J.	17.1	11.4	0-36		15		21.0	15.1	2-56		22
	L.	5.6	7.7	0-24		7		18.4	19.0	0-66		17
		Stylocheiron abbreviatum							*Thysanopoda orientalis*			
S- 2	A.	0.5	0.8	0-2	9	3	Total	3.5	2.1	2-5	2	2
	J.	3.4	3.7	0-10		7						
	L.	0.8	1.4	0-4		3						
S- 4	A.	1.6	2.7	0-11	28	8	T.	3.4	1.8	2-6	5	5
	J.	5.1	7.3	0-29		16						
	L.	5.1	7.8	0-24		11						
S- 6	A.	1.3	2.7	0-10	24	7	T.	3.9	2.3	2-10	12	12
	J.	9.6	18.5	0-92		19						
	L.	3.9	8.1	0-30		9						
S- 8	A.	2.3	5.2	0-20	22	7	T.	4.4	2.6	2-8	9	9
	J.	6.0	6.6	0-20		15						
	L.	4.6	5.9	0-24		14						
S-10	A.	1.7	6.7	0-26	15	1	T.	7.8	6.7	2-18	8	8
	J.	6.3	6.5	0-24		12						
	L.	3.9	5.9	0-20		7						

Appendix II (Continued)

CRUISE		X	S.D.	RANGE	NO. OF STATIONS SPECIES PRESENT	STAGE PRESENT	X	S.D.	RANGE	NO. OF STATIONS SPECIES PRESENT	STAGE PRESENT

Pseudeuphausia latifrons (Area D) — *Pseudeuphausia latifrons* (Area E)

CRUISE	Stage	X	S.D.	RANGE	SPECIES PRESENT	STAGE PRESENT	X	S.D.	RANGE	SPECIES PRESENT	STAGE PRESENT
S- 2	Adlt.			NOT	OCCUPIED		31.6	59.9	0-219	15	6
	Juv.						343.5	580.2	0-2061		14
	Larv.						100.1	128.4	0-395		11
S- 4	A.	374.2	804.0	0-1812	5	3	193.1	307.6	0-1035	12	10
	J.	660.4	1325.9	0-3030		4	261.2	446.7	0-1614		11
	L.	399.8	769.9	0-1773		4	78.3	135.2	0-225		8
S- 6	A.	28.8	46.8	0-120	6	3	40.8	106.8	0-363	13	3
	J.	500.3	981.1	0-2480		4	74.1	76.3	0-253		11
	L.	363.7	500.1	8-1338		6	84.1	75.1	0-255		12
S- 8	A.	29.2	43.7	0-113	6	4	23.1	36.6	0-117	12	7
	J.	92.0	106.9	28-304		6	106.8	130.6	0-414		11
	L.	59.0	66.3	0-170		5	59.1	71.6	0-210		9
S-10	A.	41.3	76.5	0-270	16	12	3.6	6.5	0-15	5	2
	J.	195.4	281.1	0-1143		14	84.2	114.1	4-281		5
	L.	311.6	299.6	24-908		16	38.6	66.0	0-154		4

Pseudeuphausia latifrons (Area F)

CRUISE	Stage	X	S.D.	RANGE	SPECIES PRESENT	STAGE PRESENT
S- 2	A.	1.3	1.5	0-4	9	5
	J.	66.6	186.6	0-564		6
	L.	0.2	0.7	0-2		1
S- 4	A.	92.7	366.1	0-1559	18	9
	J.	72.6	139.3	0-458		14
	L.	30.1	66.1	0-252		10
S- 6	A.	3.7	8.8	0-33	20	4
	J.	51.8	71.8	0-251		19
	L.	37.5	74.6	0-335		17
S- 8	A.	6.9	22.0	0-102	22	4
	J.	44.9	102.4	0-467		17
	L.	51.4	77.4	0-341		17
S-10	A.	0.0	0.0	0	14	0
	J.	12.9	18.1	0-62		9
	L.	81.8	89.4	6-334		14

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Appendix III

STANDARDIZED COUNTS, l -m NET TOWS

Pseudeuphausia latifrons

CRUISE S-1 (October 20-30, 1959)

Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv
2	52	52	--	12	6	--	13	20	101	--	--	30	6	--	--
3	92	--	56	13	2	--	4	21	6	--	--	33	11	--	--
5	1310	262	--	15	--	--	5	23	3	--	--	34	10	--	--
6	82	--	--	16	346	231	346	27	149	--	--	35	97	--	--
7	8	--	--	17	4	--	2	28	3	--	--				
8	64	9	--	19	--	53	43	29	214	214	143				

CRUISE S-2 (November 30-December 13, 1959)

Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv
6	--	8	11	15	1	--	--	22	12	12	58	29	--	--	3
8	--	2	2	16	2	--	--	23	--	15	15	30	97	522	--
9	--	16	--	17	2	12	--	24	1	69	39	31	41	285	203
10	3	--	--	18	--	14	32	25	--	112	280	32	--	--	15
11	--	1	--	19	4	1222	282	26	--	54	54				
12	--	4	--	20	219	2061	395	27	75	588	--				
13	4	564	--	21	22	129	129	28	3	67	--				

CRUISE S-3 (January 20-30, 1960)

Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv
2	138	115	115	10	--	--	58	18	53	356	36	25	--	19	19
3	--	242	61	11	--	213	1065	19	--	234	624	26	--	26	26
4	71	24	47	12	--	10900	2180	20	--	2700	13500	30	--	183	734
5	--	6	--	13	--	981	131	21	--	8310	5190	32	768	768	--
7	62	125	62	14	--	119	--	22	--	135	337				
8	361	1084	2890	16	1580	632	474	23	268	--	872				
9	--	27	216	17	473	2370	1046	24	105	17	17				

CRUISE S-4 (February 27-March 19, 1960)

Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv
1	51	49	--	14	1812	3030	1773	23	--	11	11	33	1035	45	225
2	--	--	2	15	8	380	--	24	--	30	10	34	6	170	14
3	--	21	28	16	--	4	8	25	--	11	--	35	72	--	--
8	4	--	--	17	6	--	--	26	13	39	39	36	343	200	--
9	2	--	--	18	--	56	33	27	7	21	--	37	4	14	2
10	--	--	3	19	37	18	--	28	434	1614	434	39	--	110	--
11	--	4	--	20	1559	458	153	30	25	272	2	40	78	390	104
12	8	163	85	21	--	2	4	31	6	2	2	41	--	3	--
13	--	60	139	22	32	252	252	32	314	314	157				

CRUISE S-5 (April 21-May 2, 1960)

Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv
U- 3	--	--	12	5	13	26	26	18	--	2160	3260	26	--	7	--
U- 5	--	17	--	6	--	7	3	19	257	1800	1800	27	5	--	--
U- 6	--	16	--	9	--	--	120	20	--	107	128	28	13	43	470
U- 8	--	--	36	9A	8800	9010	4514	21	--	123	204	28A	--	32	32
U- 9	80	1075	817	9B	337	449	281	22A	--	--	15	28B	32	32	117
U-10	--	241	1925	10	--	733	136	22C	--	291	2470	29	352	37	19
U-11	--	50	3773	11	--	1720	3893	22D	35	535	351	29A	28	--	83
U-12	--	--	34	12	--	--	2653	22E	--	32	291	29B	70	88	53
U-13	1287	164	99	13	--	98	1393	22F	--	--	2478	29D	8	--	--
1	--	--	2250	14	63	1838	16145	23	--	4	--	30	--	--	19
2	--	--	15	14B	118	6856	2360	23A	--	--	33	31	--	226	1093
3	6	--	--	15	92	1490	1368	24	38	9	--	32	--	43	115
4	69	--	--	16	--	2020	266	25	12	87	--	33	--	77	15

CRUISE S-6 (May 25-June 24, 1960)

Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv
1	--	--	1338	11X	--	41	30	22	--	7	30	33	363	--	--
2	--	--	8	12X	--	52	10	23	--	10	10	34	--	86	86
3X	35	87	69	13	--	41	68	24	--	21	14	35	--	9	40
4	--	--	4	14	18	394	340	25A-X	--	229	335	36	--	253	51
5	--	8	8	15	120	2480	359	26	12	10	60	37	--	95	255
6	33	148	--	16	--	34	23	27	21	35	35	38	--	93	27
7	--	32	20	17	--	17	17	28	--	87	52	39	4	46	106
8	--	8	2	18	--	13	--	30	164	29	127	40	--	13	66
9	--	42	21	19	--	26	18	31	--	195	207	41	--	--	6
10	--	251	112	20	7	53	--	32	--	57	70				

CRUISE S-7 (August 2-14, 1960)

Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv
5	32	72	--	18	--	88	9	24	--	5	--	33D	--	16	3
9	34	169	11	18A	--	22	44	25	--	--	11	34	--	2	--
10	450	212	8	18B	5	--	--	28	--	36	2	35	--	--	72
14	--	33	--	18C	--	22	11	29	11	21	21	35A	10	--	--
15	27	155	9	18E	--	29	--	30	18	62	18	36	22	22	--
16	--	16	--	19	--	23	11	32A	--	35	47	37	11	107	43
17	--	--	9	20	--	79	116	32B	--	2	--	38	63	75	263
17A	--	3	3	21	48	82	28	33B	--	--	411	41	--	3	--
17B	11	26	--	23	4	--	--	33C	10	49	20	42	25	25	--

CRUISE S-8 (September 8-October 6, 1960)

Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv
1	4	28	48	7	--	25	8	19	--	53	21	31	--	79	169
1A	--	27	48	8	--	17	50	20	--	7	87	32	60	12	36
1B	113	170	28	9	--	26	120	21	--	7	--	33	11	42	32
2	--	--	27	10	18	83	55	22B	--	--	4	34	--	6	6
3	102	--	51	11	16	16	107	24	--	2	--	37	--	85	51
4	--	23	--	12	17	9	112	25	--	--	2	38	3	160	210
5	--	16	8	14	19	110	304	26	--	--	2	39	6	--	18
5A	--	181	--	15	39	19	97	27	--	467	341	40	--	414	--
5A$_2$	--	31	--	17	--	--	57	28	--	23	56	41	56	318	131
6	--	8	8	18	--	16	98	30	117	83	--	42	24	60	--

CRUISE S-9 (November 10-24, 1960)

Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv
1	20	73	73	11	--	3	9	18-9	--	33	43	31	155	139	277
2	--	--	8	12	42	184	821	21	--	27	--	33-5	--	161	309
3	--	3	9	13(2)	--	--	24	22	--	11	11	33-8	--	13	40
5	--	--	3	15(1)	--	4	--	23	--	58	249	34	--	76	50
6	--	--	10	16(1)	1050	--	--	24	--	129	645	35	--	108	181
7	37	62	12	16(2)	759	61	41	25	58	91	128	36	--	679	142
8(10)	8	--	--	17(1)	63	6	--	26	82	738	2133	37	--	44	133
8(13)	--	237	1517	17(2)	--	46	206	28	--	58	--	38	--	--	22
8(17)	50	248	150	18-4a	10	10	--	29	--	365	2553	40	--	715	663
10	--	16	16	18-6	--	11	11	30	--	358	740	41	18	88	35

CRUISE S-10 (January 23-29, 1961)

Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv
U- 7	--	85	34	10	--	--	66	U-32	--	28	154	U-52	73	109	--
U-25	9	177	276	11	--	--	19	U-35	15	281	--	U-53	28	64	96
U-27	4	198	902	12	--	--	24	U-36	3	23	3	U-54	16	72	125
U-28	37	56	104	12B	--	2	97	U-37	--	4	2	U-55	19	--	27
U-29	2	47	62	13	54	366	122	U-38	8	68	46	U-59	--	821	--
U-30	3	9	24	15	--	--	121	U-39	635	266	25	U-60	128	10184	21
U-31	--	70	305	16	--	6	144	U-40	91	4050	319	U-61	279	7213	--
1	270	358	547	17	--	19	101	U-41	129	243	48	U-62	126	508	122
1A	188	290	125	17B	--	--	12	U-42	--	68	8	U-63	--	394	220
1B	16	178	908	18	--	30	103	U-43	--	--	9	U-64	33	17	34
2	35	71	226	18A	--	35	81	U-44	14	570	195	U-65	38	2638	1243
4	--	5	14	19	--	12	18	U-45	10	37	--	U-66	68	1188	320
5	--	6	162	19A	--	62	334	U-46	19	19	--	U-67	--	848	900
6	--	6	70	20	30	1143	669	U-47	--	3	--	U-68	3	342	348
8	--	--	7	21	13	162	473	U-50	69	394	--	U-71	--	286	406
9	--	--	6					U-51	17	--	17	U-74	3	16	35

Thysanopoda tricuspidata

Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv
— CRUISE S-2 (November 30-December 13, 1959)														

CRUISE S-2 (November 30-December 13, 1959)

Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv
8	—	—	4	13	—	4	—	18	—	—	4	25	—	—	56
9	—	6	16	14	—	—	2	21	—	—	4	26	—	14	14
10	—	2	—	15	—	—	3	22	—	—	292	28	—	5	33
11	—	—	20	16	—	—	96	23	—	91	46	29	—	—	21
12	2	7	4	17	—	—	2	24	—	10	49				

CRUISE S-4 (February 27-March 19, 1960)

Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv
2	6	9	24	10	—	—	9	21	—	—	19	31	—	—	4
3	—	—	21	11	6	2	—	22	—	32	32	33	—	4	—
4	2	—	—	12	—	4	8	23	—	—	2	34	—	—	4
5	—	—	9	15	3	—	2	24	—	—	59	35	—	—	18
6	2	—	75	16	—	—	24	25	—	4	42	36	—	26	13
7	—	—	9	17	—	2	4	26	—	—	44				
8	—	2	85	18	—	11	11	27	—	14	41				
9	—	8	16	19	—	9	—	28	—	948	372				

CRUISE S-6 (May 25-June 24, 1960)

Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv
4	—	2	10	9	—	14	14	18	2	—	—	23	4	—	10
5	—	33	98	10	—	7	7	19	—	78	52	24	—	—	35
6	—	—	105	11X	—	14	120	20	2	2	37	26	—	20	—
7	—	10	32	12X	—	—	5	21	—	15	23				
8	—	23	15	17	—	25	25	22	—	—	22				

CRUISE S-8 (September 8-October 6, 1960)

Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv
2	—	2	—	7	—	12	6	17	—	—	32	22B	—	6	6
3	—	—	4	8	—	—	25	18	—	10	58	23	—	2	—
5	—	—	24	9	—	—	17	19	—	35	32	24	—	14	36
5A	—	30	30	10	—	—	2	20	—	7	29				
5A$_2$	—	2	—	11	—	2	8	22	—	—	32				

CRUISE S-10 (January 23-29, 1961)

Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv
U-25	—	—	4	6	—	1	35	12	—	—	24	18A	—	13	6
U-27	—	2	—	7	—	8	23	12B	—	—	37	19	—	—	6
1B	—	2	—	8	—	—	13	16	—	—	12	19A	—	2	18
3	—	—	39	9	—	30	36	17	—	32	13	20	—	6	24
4	—	10	15	10	6	12	6	17B	6	6	6				
5	—	26	32	11	—	—	19	18	—	6	18				

Thysanopoda monacantha

CRUISE S-2 (November 30-December 13, 1959)

Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv
8	—	—	2	11	1	—	1	15	—	1	—	23	—	—	2
9	—	—	2	12	—	—	2	16	2	—	—	24	—	—	1
10	—	—	5												

CRUISE S-4 (February 27-March 19, 1960)

Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv
4	—	—	6	11	—	—	8	21	—	—	6	27	—	—	2
5	—	—	4	12	—	—	2	22	—	—	8	32	—	—	2
6	—	—	4	16	—	—	10	24	—	—	2	34	—	2	—
7	—	—	2	17	—	—	2	25	—	—	2				
10	—	—	2	18	—	—	6	26	—	—	2				

CRUISE S-6 (May 25-June 24, 1960)

Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv
3X	—	—	4	9	—	—	6	18	—	—	2	24	—	—	7
4	—	—	2	10	—	2	6	20	—	—	7	26	—	—	10
5	—	—	18	11X	—	—	8	21	—	—	6	28	—	3	—
6	—	7	40	16	—	2	2	22	—	—	4				
7	—	—	4	17	—	2	2	23	—	—	10				

CRUISE S-8 (September 8-October 6, 1960)

Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv
1B	—	—	2	7	—	2	4	10	—	—	11	22B	—	2	—
3	—	—	2	8	—	—	8	11	—	—	2	24	—	2	—
5	—	2	2	9	—	—	2	17	—	—	4	26	—	—	2
5A	4	—	—												

CRUISE S-10 (January 23-29, 1961)

Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv
1B	—	—	2	8	—	—	13	12B	—	—	6	18A	1	—	6
4	—	—	2	9	—	1	12	16	—	—	5	19	—	—	12
5	—	—	32	10	—	—	18	17	—	—	25				
6	—	—	24	11	—	5	3	17B	—	—	6				
7	—	—	23	12	—	—	18	18	—	6	42				

Thysanopoda aequalis

CRUISE S-2 (November 30–December 13, 1959)

Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv
8	—	—	56	11	1	20	20	13	—	4	—	22	—	—	2
9	3	5	—	12	4	—	—	16	4	32	16	24	—	3	—
10	—	20	—												

CRUISE S-4 (February 27–March 19, 1960)

Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv
2	—	2	—	9	—	2	16	18	—	—	55	27	—	—	14
3	—	—	7	10	—	—	35	19	14	46	9	32	—	2	—
4	24	12	50	11	20	59	29	20	2	23	—	33	—	—	2
5	—	—	18	12	—	—	31	21	—	—	46	34	—	14	—
6	15	45	15	15	—	5	50	24	—	—	30				
7	—	9	67	16	—	8	40	25	57	21	21				
8	2	38	9	17	10	26	26	26	—	—	4				

CRUISE S-6 (May 25–June 24, 1960)

Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv
3X	5	8	2	9	—	4	4	16	—	4	2	22	—	7	15
4	—	19	29	10	14	30	15	17	—	17	17	23	4	18	10
5	—	41	33	11X	—	16	20	18	8	26	—	24	—	2	14
6	2	23	16	12X	25	15	20	19	—	8	—	26	10	—	—
7	—	10	32	13	—	14	7	20	4	7	30				
8	15	—	—	14	—	36	—	21	—	15	—				

CRUISE S-8 (September 8–October 6, 1960)

Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv
2	—	—	4	6	2	—	—	17	—	—	4	23	—	12	12
3	—	6	—	7	—	4	4	18	2	24	49	24	7	14	7
4	—	6	4	8	—	—	8	19	5	43	32	25	—	—	2
5	—	16	41	9	—	—	2	20	—	7	—	26	—	2	2
5A	9	10	—	10	6	—	2	21	4	22	—				
5A₂	6	2	—	11	—	2	16	22B	—	—	2				

CRUISE S-10 (January 23–29, 1961)

Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv
1B	—	4	—	7	—	39	47	12B	—	8	—	18A	9	23	6
2	—	2	—	8	7	20	13	15	—	18	24	19	12	18	12
3	—	5	46	9	7	18	42	16	—	18	12	19A	—	2	—
4	—	24	14	10	30	42	24	17	—	38	13	20	—	12	—
5	6	45	6	11	—	6	6	17B	49	56	44				
6	7	29	23	12	—	12	6	18	18	24	66				

Thysanopoda orientalis *Thysanopoda pectinata*

CRUISE S-2 (November 30–December 13, 1959)

Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv
9	—	—	5	17	—	—	2	9	—	—	5				

CRUISE S-4 (February 27–March 19, 1960)

Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv
5	—	—	2	17	—	—	6	5	—	—	2				
11	—	2	2	19	—	—	2								
15	—	5	—												

CRUISE S-6 (May 25–June 24, 1960)

Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv
3X	—	—	3	16	—	—	2	4	—	4	—	19	—	2	—
4	—	—	4	17	—	2	—	6	—	2	—				
5	—	—	4	19	—	—	4								
7	—	—	2	23	—	4	—								
8	—	2	2	24	—	—	2								
9	—	—	6	26	—	—	10								

CRUISE S-8 (September 8–October 1960)

Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv
3	—	—	4	8	—	—	2	5A₂	—	4	—	19	—	—	3
4	—	—	2	9	—	—	8	18							
5	—	—	8	11	—	2	4								
5A	—	—	2	19	—	—	6								
5A2	—	2	—												

CRUISE S-10 (January 23–29, 1961)

Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv
3	—	—	2	9	—	—	18	3	—	—	3	19	—	1	—
4	—	—	8	16	—	—	2	6	—	—	6				
6	—	6	—	17B	—	—	6								
7	—	—	2	18	—	—	18								

Euphausia diomedeae

Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv
CRUISE S-2 (November 30-December 13, 1959)															
8	—	—	28	12	18	106	71	22	—	—	2	26	—	41	—
9	19	94	172	13	4	—	27	23	—	30	61				
10	—	—	94	16	32	—	96	24	—	—	29				
11	1	60	111	17	24	24	71	25	—	—	3				
CRUISE S-4 (February 27-March 19, 1960)															
2	97	—	366	8	47	—	113	17	26	13	115	23	—	2	108
3	—	—	85	9	2	—	117	18	—	—	100	24	—	—	227
4	6	—	49	10	—	—	9	19	74	46	497	25	21	—	462
5	—	—	9	11	88	15	324	20	80	23	11	26	2	—	26
6	30	90	150	15	2	33	100	21	—	—	74	32	—	—	78
7	—	—	9	16	—	2	8	22	725	347	—	33	—	16	90
CRUISE S-6 (May 25-June 24, 1960)															
2	2	2	—	8	75	53	182	16	—	23	136	23	201	210	862
3X	329	87	1365	9	—	—	310	17	—	—	25	24	—	—	35
4	—	—	68	10	119	149	528	18	91	26	91	26	15	50	421
5	—	—	138	11X	—	—	16	20	69	23	60	27	—	—	7
6	72	108	215	12X	67	72	485	21	—	—	2	28	—	—	3
7	—	—	94	13	135	974	378	22	—	—	419				
CRUISE S-8 (September 8-October 6, 1960)															
1A	—	—	8	5A₂	61	184	286	12	4	52	172	22B	—	—	2
2	6	10	194	6	2	17	8	14	—	—	8	24	24	152	72
3	61	41	30	8	14	41	348	18	57	25	588	25	—	—	7
4	—	—	54	9	—	—	52	19	140	106	676	26	11	23	46
5	—	—	58	10	286	102	248	21	120	180	209				
5A	130	241	130	11	8	33	24	22	—	—	8				
CRUISE S-10 (January 23-29, 1961)															
2	77	21	127	8	10	—	91	13	—	—	27	18A	24	23	87
3	—	7	105	9	24	24	155	15	6	6	6	19	24	23	76
4	—	—	5	10	30	18	54	16	—	—	18	20	—	—	47
5	—	—	13	12	—	—	6	17B	18	31	24				
6	18	6	93	12B	—	—	219	18	30	18	139				

Euphausia pseudogibba

Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv
CRUISE S-2 (November 30-December 13, 1959)															
9	3	16	—	12	18	18	—	16	5	—	—	23	—	—	15
11	6	10	—	13	—	—	2								
CRUISE S-4 (February 27-March 19, 1960)															
2	49	—	—	8	—	19	—	15	—	8	—	22	8	32	—
4	18	24	—	9	—	2	—	17	—	13	—	24	—	—	59
5	—	—	9	10	—	—	9	19	6	9	—	25	—	21	—
6	15	—	—	11	6	15	—	20	—	34	—				
CRUISE S-6 (May 25-June 24, 1960)															
3X	—	—	35	10	7	45	—	18	13	—	13	23	10	10	28
4	—	—	10	12X	26	26	—	19	—	8	26	24	—	—	14
6	—	32	—	13	95	41	27	20	2	16	30	26	10	—	20
7	—	—	2	16	—	—	22	21	—	—	48				
8	2	—	—	17	—	—	8	22	—	—	15				
CRUISE S-8 (September 8-October 6, 1960)															
2	—	17	10	6	—	2	—	12	—	9	—	24	29	36	7
3	8	10	51	8	—	8	17	18	8	8	98	26	—	—	11
4	—	—	8	9	—	—	9	19	11	—	74				
5A	—	20	10	10	74	110	27	20	—	—	14				
5A₂	4	—	—	11	—	2	2	21	22	7	7				
CRUISE S-10 (January 23-29, 1961)															
2	—	—	14	8	7	7	13	16	—	—	30	19	1	24	18
3	—	13	79	9	1	12	24	17	—	—	6	20	—	—	12
5	13	—	19	10	6	—	—	17B	—	6	31	21	—	—	19
6	12	6	—	11	—	—	6	18	—	—	12				
7	—	—	16	12	—	—	12	18A	6	6	6				

Euphausia sanzoi *Euphausia mutica*

Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv

CRUISE S-2 (November 30-December 13, 1959)

Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv
11	—	1	—	24	—	—	1	17	2	—	—
23	—	38	2	26	—	14	—				

CRUISE S-4 (February 27-March 19, 1960)

Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv
2	—	2	—	15	—	2	—	4	6	—	—	17	2	—	—
6	—	2	—	25	—	147	—	6	62	—	—	25	2	—	—
13	—	2	—	33	—	855	45	15	2	—	—	26	—	2	—
14	—	—	62	34	—	—	2								

CRUISE S-6 (May 25-June 24, 1960)

Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv
2	2	2	—	15	—	75	—
3X	—	—	5	16	—	2	—
8	—	4	—	18	—	39	—
9	—	—	2	26	—	70	451
10	—	6	—	27	—	—	21
12X	—	—	2	28	—	—	19
14	—	—	233	33	25	2	—

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CRUISE S-8 (May 25-June 24, 1960)

Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv
1A	—	5	5	8	2	2	604	8	2	—	—	10	2	—	—
1B	—	4	2	10	—	2	4								
3	—	—	31	12	—	2	—								
5A	—	30	—	21	—	66	—								
5A$_2$	—	71	—	24	2	427	—								
6	—	865	—	26	—	42	—								
7	—	14	—												

CRUISE S-10 (January 23-29, 1961)

Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv
U-25	—	13	71	9	—	—	6	10	2	—	—
U-27	—	—	32	12B	—	—	1101				
U-28	—	—	2	13	—	—	41				
1	—	8	—	15	—	—	6				
1A	—	24	—	18A	—	1	—				
1B	—	2	24	19	—	—	29				
2	—	14	21	19A	—	2	—				
3	—	2	—	20	—	18	6				
6	—	6	—	21	—	—	12				

Euphausia similis

Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv

CRUISE S-4 (February 27-March 19, 1960)

Sta No	Adlt	Juv	Larv
2	--	3	--
20	--	3	--

CRUISE S-6 (May 25-June 24, 1960)

Sta No	Adlt	Juv	Larv
3Y	--	--	2

CRUISE S-8 (September 8-October 6, 1960)

Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv
3	1	--	--	10	1	--	--
5A	--	--	1				

(App. III, contd.)

Euphausia tenera

CRUISE S-2 (November 30-December 13, 1959)

Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv
8	—	—	28	14	—	—	5	23	—	562	—	29	—	5	—
9	126	94	—	16	192	80	16	24	—	127	157	30	—	2	—
10	—	5	—	17	83	118	94	25	—	561	—				
11	121	20	—	21	—	2	—	26	—	41	—				
12	35	176	—	11	—	—	1075	28	—	5	—				

CRUISE S-4 (February 27-March 19, 1960)

Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv
2	147	294	—	10	—	—	9	19	46	193	156	27	—	—	34
3	—	36	92	11	147	132	118	20	122	92	31	32	—	—	78
4	12	37	125	12	—	—	8	21	—	—	56	33	—	—	225
5	—	—	36	14	—	2	—	22	32	347	32	34	—	—	42
6	90	261	105	15	82	33	16	23	—	—	32	35	2	—	—
7	—	9	191	16	—	—	40	24	—	—	79				
8	75	38	57	17	51	26	13	25	21	42	21				
9	—	16	31	18	—	—	89	26	—	—	52				

CRUISE S-6 (May 25-June 24, 1960)

Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv
3X	35	138	35	9	—	14	14	17	—	34	67	23	82	74	10
4	—	10	29	10	44	97	30	18	156	104	13	24	—	7	14
5	8	41	16	11X	—	8	37	19	—	16	70	26	10	10	10
6	91	246	33	12X	67	67	10	20	53	92	39	27	—	7	—
7	—	—	20	13	63	41	—	21	—	65	65				
8	61	129	15	16	—	46	23	22	—	—	37				

CRUISE S-8 (September 8-October 6, 1960)

Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv
2	10	17	62	5A2	163	102	286	10	120	101	—	19	53	275	—
3	20	10	20	6	17	25	—	11	4	8	—	20	—	7	2
4	—	78	70	7	—	—	8	12	—	9	9	21	67	22	—
5	—	66	66	8	41	75	8	17	—	—	8	24	29	14	—
5A	90	50	60	9	—	17	—	18	57	163	90	26	—	29	6

CRUISE S-10 (January 23-29, 1961)

Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv
U-25	4	6	—	7	—	8	23	13	—	3	—	19	88	163	18
1B	8	8	42	8	52	72	20	15	6	6	24	19A	—	24	47
2	14	79	14	9	60	113	113	16	—	36	48	20	6	41	12
3	20	39	20	10	127	102	66	17	—	25	25	21	—	—	13
4	—	5	5	11	—	19	39	17B	94	62	6				
5	32	39	32	12	—	18	79	18	36	84	36				
6	29	52	23	12B	—	73	73	18A	64	64	17				

Euphausia recurva

Sta No	Adlt	Juv	Larv

CRUISE S-4 (February 27-March 19, 1960)

Sta No	Adlt	Juv	Larv
4	2	—	—

Nematoscelis atlantica

CRUISE S-6 (May 25-June 24, 1960)

Sta No	Adlt	Juv	Larv
2	—	2	—

Thysanopoda cristata

CRUISE S-10 (January 23-29, 1961)

Sta No	Adlt	Juv	Larv
7	—	—	2

Thysanopoda egregia

CRUISE S-4 (February 27-March 19, 1960)

Sta No	Adlt	Juv	Larv
5	—	—	4

Nematoscelis tenella

CRUISE S-2 (November 30-December 13, 1959)

Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv
8	—	4	—	11	—	4	10	15	—	1	—	23	—	15	—
9	2	31	—	12	4	—	—	16	—	4	—	24	—	11	—
10	—	—	5	13	—	—	4								

CRUISE S-4 (February 27-March 19, 1960)

Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv
2	9	24	—	8	2	4	9	16	—	—	2	21	—	2	6
4	—	2	—	9	—	21	—	17	—	4	2	22	—	34	—
5	—	4	—	10	—	2	7	18	—	22	—	24	—	10	—
6	—	6	—	11	—	26	—	19	—	4	—	25	—	63	—
7	—	9	—	15	—	2	—	20	2	11	23	27	—	—	21

CRUISE S-6 (May 25-June 24, 1960)

Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv
3X	—	2	—	8	—	12	8	13	—	28	—	24	—	7	—
4	—	4	10	9	—	4	—	17	—	2	8	25AX	—	—	2
5	—	24	8	10	—	4	—	20	—	14	—	26	—	4	—
6	—	18	7	11X	—	—	2	21	—	2	—	27	—	2	—
7	—	—	6	12X	—	2	—	23	—	—	10	28	—	—	3

CRUISE S-8 (September 8-October 6, 1960)

Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv
2	—	10	—	5A2	4	4	10	17	—	—	2	24	—	7	—
3	—	10	30	6	—	17	16	18	—	16	16	26	—	6	—
4	—	2	—	8	—	10	17	19	—	—	22				
5	—	24	24	9	—	2	—	20	—	2	—				
5A	—	10	50	10	—	27	—	21	—	2	—				

CRUISE S-10 (January 23-29, 1961)

Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv
U-25	—	2	—	7	—	8	—	12B	—	6	—	18A	—	18	—
2	—	4	—	8	2	27	—	15	—	—	6	19	—	12	12
4	—	24	—	9	—	30	12	17	—	25	—				
5	6	12	6	10	—	36	18	17B	—	12	12				
6	—	18	—	12	—	6	24	18	—	36	—				

Nematoscelis microps

CRUISE S-2 (November 30-December 13, 1959)

Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv
8	—	—	28	11	9	10	10	14	—	4	—	17	—	—	3
9	2	31	16	12	2	7	35	15	—	1	—	24	—	—	11
10	—	—	5	13	—	—	4	16	—	20	32	26	—	2	—

CRUISE S-4 (February 27-March 19, 1960)

Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv
2	10	24	24	9	—	8	16	19	—	35	46	27	—	—	7
3	—	—	14	10	—	9	18	20	—	2	23	28	—	3	—
4	—	36	—	11	—	93	118	21	—	19	19	32	—	16	—
5	—	—	9	15	—	3	—	22	2	8	32	33	—	16	—
6	4	17	15	16	—	2	—	23	—	6	—	34	—	2	—
7	—	29	9	17	—	21	2	24	—	40	30				
8	—	18	28	18	—	11	33	25	—	42	—				

CRUISE S-6 (May 25-June 24, 1960)

Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv
2	—	6	—	9	—	23	14	17	—	25	—	24	—	7	7
3X	—	348	69	10	—	7	—	18	13	13	—	25AX	—	2	—
4	—	29	10	11X	—	2	10	19	—	26	8	26	12	20	—
5	2	18	—	12X	5	26	3	20	—	78	16	27	—	28	7
6	7	35	—	13	28	122	—	21	—	8	8				
7	—	10	10	14	—	143	18	22	—	15	7				
8	—	76	23	16	—	23	—	23	2	—	10				

CRUISE S-8 (September 8-October 6, 1960)

Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv
1B	—	—	2	5A2	4	41	61	11	2	49	—	21	—	7	—
2	17	64	10	6	8	50	—	12	—	26	43	22	—	2	—
3	—	195	154	7	—	25	8	17	—	—	16	23	—	12	—
4	—	18	86	8	2	35	91	18	10	25	33	24	—	7	—
5	—	49	49	9	—	35	17	19	—	37	32	25	—	7	—
5A	2	40	20	10	9	28	—	20	—	7	43	26	—	6	6

CRUISE S-10 (January 23-29, 1961)

Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv
3	—	4	85	8	3	40	46	12B	—	—	122	18A	—	35	12
4	—	14	5	9	—	25	114	16	—	42	24	19	1	6	12
5	—	44	13	10	6	66	36	17	—	—	13	19A	—	—	23
6	6	30	—	11	—	32	32	17B	6	18	37	20	—	1	—
7	—	8	—	12	—	2	12	18	2	18	—	21	—	—	2

Nematoscelis gracilis

CRUISE S-2 (November 30-December 13, 1959)

Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv
8	--	4	28	13	--	15	--	23	--	30	122	29	--	3	--
9	2	16	--	15	--	7	14	24	--	--	88	30	2	2	--
10	--	20	--	16	4	112	16	25	--	3	5				
11	1	10	10	17	--	59	24	26	--	14	--				
12	35	--	--	22	--	2	4	28	--	2	--				

CRUISE S-4 (February 27-March 19, 1960)

Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv
2	9	49	--	10	--	3	9	20	6	11	11	28	--	127	62
3	--	14	99	11	2	29	15	21	9	9	37	32	--	313	196
4	14	25	37	12	8	16	16	22	--	315	158	33	45	90	45
5	--	4	36	15	16	32	33	23	--	--	64	34	--	42	--
6	15	60	60	16	--	16	8	24	--	30	70	35	--	9	--
7	--	18	95	17	4	--	52	25	6	126	42				
8	4	--	57	18	--	11	33	26	--	26	117				
9	2	24	16	19	9	4	9	27	--	--	54				

CRUISE S-6 (May 25-June 24, 1960)

Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv
2X	--	6	--	8	23	174	30	16	--	11	57	22	--	7	--
3X	17	277	35	9	--	84	63	17	8	25	8	23	--	18	28
4	10	20	--	10	--	89	22	18	--	78	--	24	2	21	7
5	2	33	16	11X	--	16	30	19	--	88	8	25A-X	--	8	23
6	14	286	16	12X	2	36	41	20	7	46	--	26	3	180	30
7	--	86	72	13	14	27	27	21	--	40	--	27	7	7	--

CRUISE S-8 (September 8-October 6, 1960)

Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv
2	2	8	17	6	--	75	--	12	--	9	--	22	--	8	--
3	10	91	61	7	--	16	16	17	--	24	40	22B	--	8	--
4	--	8	--	8	--	50	41	18	--	66	90	23	--	8	--
5	--	25	25	9	--	2	--	19	--	85	32	24	21	79	--
5A	--	50	50	10	9	28	--	20	--	181	58	25	7	7	--
5A$_2$	2	173	31	11	--	24	16	21	15	30	--	26	--	6	17

CRUISE S-10 (January 23-29, 1961)

Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv
U-25	--	--	14	6	6	41	6	12	--	24	24	18	12	30	48
1B	--	2	--	7	--	26	--	12B	--	24	--	18A	6	18	17
2	--	4	--	8	14	7	--	15	--	12	24	19	--	29	--
3	--	33	13	9	6	42	60	16	--	18	18	19A	--	16	23
4	--	20	10	10	30	54	12	17	--	12	25	20	--	12	6
5	13	32	6	11	--	18	6	17B	12	18	6				

Stylocheiron abbreviatum

CRUISE S-2 (November 30-December 13, 1959)

Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv
8	—	9	—	11	1	1	1	14	—	4	—	16	2	2	—
9	—	3	2	12	2	—	—	15	—	2	—	23	—	—	4
10	—	10	—												

CRUISE S-4 (February 27-March 19, 1960)

Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv
2	—	9	24	11	—	29	—	19	4	—	18	26	—	—	2
3	—	2	4	12	—	8	16	20	11	22	—	27	2	—	—
4	—	4	—	15	—	2	8	21	—	2	6	32	—	4	—
6	2	—	—	16	—	2	4	22	4	2	—				
8	4	—	2	17	—	2	—	24	—	6	2				
10	—	6	—	18	2	4	22	25	4	4	—				

CRUISE S-6 (May 25-June 24, 1960)

Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv
2	2	2	—	8	10	—	30	14	—	3	—	23	2	—	—
3X	3	92	—	9	—	9	7	17	—	8	—	24	—	—	2
4	2	2	—	10	9	14	—	18	—	13	26	25AX	—	2	2
5	—	10	—	11X	—	6	—	19	—	2	—	26	—	10	—
6	—	7	—	12X	3	5	—	20	—	23	—	27	—	—	2
7	—	4	4	13	—	16	14	21	—	—	6	28	—	3	—

CRUISE S-8 (September 8-October 6, 1960)

Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv
3	14	2	—	7	—	4	—	17	—	—	2	22B	—	14	—
4	—	6	2	8	—	8	—	18	—	8	24	23	—	—	2
5	—	16	—	9	—	4	—	19	3	11	11	24	2	7	—
5A	—	20	10	10	2	—	2	20	2	2	—	26	—	—	2
5A$_2$	20	20	10	11	—	—	4	21	—	—	7				
6	8	8	8	12	—	—	9	22	—	2	8				

CRUISE S-10 (January 23-29, 1961)

Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv
3	—	2	—	7	—	2	—	11	—	4	13	18	—	—	6
4	—	10	—	8	—	7	20	15	—	—	6	19	—	6	6
5	26	13	—	9	—	6	6	17	—	2	—	19A	—	—	2
6	—	12	—	10	—	24	—	17B	—	6	—				

Stylocheiron carinatun

Stylocheiron carinatum

Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv

CRUISE S-2 (November 30-December 13, 1959)

Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv
8	14	182	126	13	—	40	40	21	2	—	—	27	13	—	—
9	235	377	—	14	—	27	11	22	—	129	—	23	—	3	—
10	15	84	15	15	7	7	7	23	—	790	198				
11	91	201	—	16	146	240	32	24	10	422	103				
12	53	194	18	17	36	36	59	26	41	583	41				

CRUISE S-4 (February 27-March 19, 1960)

Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv
2	343	49	73	10	—	179	136	19	147	194	28	27	14	116	54
3	4	21	85	11	118	176	44	20	153	973	22	28	—	496	—
4	74	150	87	12	16	93	109	21	28	93	298	32	78	706	432
5	—	46	18	14	—	9	—	22	63	347	32	33	90	903	315
6	150	105	—	15	82	99	49	23	2	695	342	34	14	410	283
7	38	191	410	16	16	120	200	24	40	79	40	35	—	36	2
8	179	237	75	17	116	167	116	25	610	210	84	36	66	13	—
9	31	225	16	18	22	111	244	26	26	129	52	37	—	—	2

CRUISE S-6 (May 25-June 24, 1960)

Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv
2	—	176	—	10	342	148	141	19	34	122	104	27	44	72	14
3X	156	329	155	11X	20	100	55	20	493	273	37	28	—	23	—
4	21	58	57	12X	227	198	62	21	15	33	41	32	—	58	—
5	41	90	40	13	189	108	135	22	7	202	180	33	745	79	20
6	244	376	80	14	—	—	36	23	228	393	183	34	58	81	2
7	30	40	10	16	68	57	—	24	7	56	21	40	53	66	26
8	99	288	68	17	76	109	92	25AX	91	99	38				
9	35	70	105	18	143	91	26	26	251	100	40				

CRUISE S-7 (August 2-14, 1960)

Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv
29	—	3	—	38	25	62	—

CRUISE S-8 (September 8-October 6, 1960)

Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv
1	—	8	—	7	8	106	25	19	180	507	74	27	4	103	8
1A	5	16	11	8	41	207	58	20	43	79	22	28	—	35	—
2	35	72	97	9	9	26	52	21	252	397	45	32	—	3	—
3	61	61	71	10	230	130	46	22	—	267	40	34	6	126	13
4	2	164	31	11	8	82	33	22B	6	24	18	37	—	59	—
5	66	164	131	12	—	52	35	23	29	75	35	38	17	75	—
5A	342	130	80	14	—	8	34	24	275	246	29	39	84	174	114
5A$_2$	102	143	51	17	32	251	32	25	22	129	36	41	9	9	—
6	599	58	—	18	172	401	98	26	2	2	—				

CRUISE S-10 (January 23-29, 1961)

Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv
U-25	4	68	65	5	525	415	90	11	58	113	51	17B	206	162	24
U-27	—	—	2	6	116	441	58	12	36	200	109	18	199	556	78
1B	2	110	25	7	31	101	186	12B	122	392	97	18A	232	232	52
2	7	28	14	8	92	195	27	15	27	84	72	19	146	240	100
3	79	86	131	9	89	113	143	16	36	102	60	19A	8	62	47
4	39	203	63	10	139	628	326	17	13	31	13	20	12	18	—

Stylocheiron maximum   Stylocheiron suhmii

Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv

CRUISE S-2 (November 30-December 13, 1959)

Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv
8	—	—	2	11	—	3	—	11	—	20	—

CRUISE S-4 (February 27-March 19, 1960)

Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv
4	—	—	2	17	—	—	6	2	4	4	—	12	—	2	—
6	—	2	4	18	—	—	2	4	4	2	—	17	2	—	—
9	—	—	6	21	—	—	4	5	2	—	—	19	2	—	—
11	—	—	2	22	—	—	2	7	4	—	—	24	4	—	—
12	—	—	2	23	—	—	2	10	2	—	—	32	2	—	—
15	—	—	2												

CRUISE S-6 (May 25-June 24, 1960)

Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv
4	—	—	2	21	—	—	2	2	11	—	—	12X	2	—	—
13	—	—	2	22	—	—	2	3X	5	—	—	17	2	—	—
16	—	—	2	23	—	—	2	4	2	—	—	22	2	—	—
								5	—	4	—	25A-X	3	—	—
								6	2	—	—	26	10	—	—
								7	4	—	—	27	7	—	—
								9	4	—	—	33	2	—	—
								10	4	7	—				

CRUISE S-8 (September 8-October 6, 1960)

Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv
2	—	—	4	8	—	—	8	4	2	—	—	11	—	2	—
3	—	—	4	9	—	2	2	5	2	—	—	12	—	2	—
4	—	—	2	22B	—	—	12	5A	—	—	10	23	—	2	—
5A$_2$	—	—	4												

CRUISE S-10 (January 23-29, 1961)

Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv
3	—	—	2	11	—	—	2	3	—	3	—	12	—	12	—
4	—	—	5	16	—	—	3	4	—	2	—	15	—	6	—
10	—	—	18	18	—	—	6								

Stylocheiron affine

CRUISE S-2 (November 30-December 13, 1959)

CENTRAL Sta No	Adlt	Juv	Larv		Sta No	INDO-AUSTRALIAN Adlt	Juv	WEST EQUATORIAL Adlt	Juv	IA & WE Larv		Sta No	INDO-AUSTRALIAN Adlt	Juv	WEST EQUATORIAL Adlt	Juv	IA & WE Larv
					8	—	7	—	56	42		14	—	7	—	11	14
					9	5	—	2	—	7		15	—	7	—	12	—
					10	—	—	31	—	5		16	11	5	48	16	16
					11	10	30	30	—	71		17	—	7	3	—	—
					12	—	2	—	2	35		24	—	—	—	—	3
					13	—	2	2	13	27							

CRUISE S-4 (February 27-March 19, 1960)

CENTRAL Sta No	Adlt	Juv	Larv		Sta No	INDO-AUSTRALIAN Adlt	Juv	WEST EQUATORIAL Adlt	Juv	IA & WE Larv		Sta No	INDO-AUSTRALIAN Adlt	Juv	WEST EQUATORIAL Adlt	Juv	IA & WE Larv
4	2	—	—		2	49	—	28	—	72		18	—	55	4	11	22
5	—	2	—		3	—	—	—	21	228		19	9	9	18	18	18
15	—	3	—		4	—	2	12	—	25		20	—	23	34	23	—
20	2	—	—		5	—	11	18	—	54		21	4	—	19	9	97
21	—	2	—		6	—	—	15	75	90		22	—	4	20	95	2
25	—	2	—		7	—	—	—	2	9		23	—	2	—	4	119
					8	—	4	9	38	75		24	—	2	20	20	—
					9	—	—	—	16	3		25	—	4	42	2	7
					10	—	2	—	35	26		26	—	—	9	—	5
					11	4	15	29	15	15		27	—	5	—	—	—
					12	—	8	2	8	32		28	—	—	6	—	2
					15	3	—	16	33	100		32	—	2	—	8	135
					16	2	2	4	12	16		33	—	—	—	225	6
					17	—	20	39	39	—		34	—	—	—	28	

CRUISE S-6 (May 25-June 24, 1960)

CENTRAL Sta No	Adlt	Juv	Larv		Sta No	INDO-AUSTRALIAN Adlt	Juv	WEST EQUATORIAL Adlt	Juv	IA & WE Larv		Sta No	INDO-AUSTRALIAN Adlt	Juv	WEST EQUATORIAL Adlt	Juv	IA & WE Larv
2	—	11	—		2	—	17	—	57	—		16	2	11	8	11	—
3X	3	—	—		3X	3	—	10	12	2		17	2	8	6	8	25
6	2	—	—		4	4	—	19	38	38		18	—	39	2	—	13
7	2	—	—		5	4	—	8	24	—		19	2	2	8	—	26
8	—	4	—		6	33	42	16	24	7		20	2	16	39	83	23
9	—	—	2		7	4	—	8	—	10		21	8	—	8	15	—
10	2	—	—		8	8	23	30	23	31		22	—	2	—	7	7
13	—	4	—		9	—	—	7	—	7		23	2	2	18	42	—
16	—	2	—		10	—	—	—	15	7		24	2	—	4	7	—
25AX	2	—	—		11X	6	4	8	18	—		25AX	—	—	15	15	—
27	—	4	—		12X	26	21	57	21	10		26	10	—	30	50	20
					13	14	95	14	54	—		27	21	—	58	28	—
					14	—	18	—	54	—		28	—	—	—	—	13
					15	—	—	—	3	—		33	—	—	10	137	—

CRUISE S-8 (September 8-October 6, 1960)

CENTRAL Sta No	Adlt	Juv	Larv		Sta No	INDO-AUSTRALIAN Adlt	Juv	WEST EQUATORIAL Adlt	Juv	IA & WE Larv		Sta No	INDO-AUSTRALIAN Adlt	Juv	WEST EQUATORIAL Adlt	Juv	IA & WE Larv
2	—	6	—		1A	—	—	5	3	8		14	—	16	4	—	—
3	—	2	—		1B	2	8	22	4	4		17	—	16	—	16	32
4	—	—	2		2	10	62	10	80	20		18	8	16	6	—	33
5A	4	—	—		3	10	20	20	92	51		19	53	63	21	—	22
5A2	4	2	—		4	16	—	31	258	31		20	—	7	7	22	14
10	—	2	—		5	—	—	33	164	115		21	—	—	7	15	—
17	—	4	—		5A	4	—	80	50	10		22	6	—	2	—	16
					5A2	10	10	61	92	10		22B	18	—	6	6	18
					6	17	33	8	25	8		23	12	17	2	6	12
					7	2	8	6	25	25		24	36	58	36	58	29
					8	8	25	—	—	33		25	7	14	14	57	43
					9	6	9	9	17	9		26	6	11	—	34	6
					10	18	46	46	18	—		27	—	4	2	—	—
					11	6	—	8	25	8		32	—	—	—	3	—
					12	—	4	4	—	—							

CRUISE S-10 (January 23-29, 1961)

CENTRAL Sta No	Adlt	Juv	Larv		Sta No	INDO-AUSTRALIAN Adlt	Juv	WEST EQUATORIAL Adlt	Juv	IA & WE Larv		Sta No	INDO-AUSTRALIAN Adlt	Juv	WEST EQUATORIAL Adlt	Juv	IA & WE Larv
4	—	2	—		3	2	20	20	7	26		12	12	—	6	—	24
5	—	19	—		4	10	5	5	5	10		15	6	12	—	—	—
					5	5	—	32	19	13		16	—	18	12	18	—
					6	—	29	17	6	12		17	3	—	3	—	—
					7	—	16	—	8	16		17B	—	—	25	12	19
					8	7	39	3	7	52		18	12	—	6	12	6
					9	1	72	6	6	77		18A	29	6	12	6	6
					10	6	48	12	12	—		19	1	18	12	12	76
					11	6	32	6	—	32		20	—	—	6	—	—

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Stylocheiron microphthalma

CRUISE S-2 (November 30-December 13, 1959)

Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv
8	—	14	—	12	—	35	—	15	29	—	—	23	61	—	30
9	16	—	—	13	—	13	—	17	3	—	—	24	10	39	—
10	26	—	—	14	4	—	5	18	4	—	—	26	—	41	—
11	20	—	20												

CRUISE S-4 (February 27-March 19, 1960)

Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv
2	9	—	24	10	51	—	35	19	28	18	—	27	7	—	7
3	—	—	21	11	59	59	74	20	34	—	23	28	—	62	—
4	37	—	50	12	—	16	8	21	37	—	37	32	—	39	78
5	18	—	27	13	—	—	2	22	32	—	32	33	16	—	45
6	60	—	105	15	8	—	—	23	—	21	42	34	14	14	—
7	33	—	48	16	—	24	40	24	20	—	—	35	18	—	2
8	94	—	57	17	26	—	26	25	63	21	—	36	13	—	—
9	—	16	93	18	—	—	55	26	7	22	7				

CRUISE S-6 (May 25-June 24, 1960)

Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv
2	9	—	—	9	21	7	14	18	26	65	65	25AX	53	8	8
3X	69	—	—	10	22	45	52	19	26	18	—	26	50	40	10
4	10	10	10	11X	18	6	18	20	23	30	16	27	21	—	7
5	4	—	8	12X	36	21	77	21	48	25	—	28	3	—	3
6	49	49	24	13	41	27	—	22	7	—	7	32	2	—	—
7	42	—	10	16	23	—	23	23	36	—	—	33	10	—	—
8	23	—	15	17	42	—	53	24	—	—	7	34	2	—	2

CRUISE S-8 (September 8-October 6, 1960)

Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv
1B	—	2	—	6	8	8	8	18	24	24	41	24	36	14	7
2	6	—	10	7	12	2	—	19	53	53	53	25	4	—	7
3	31	10	—	8	2	—	8	20	29	36	7	26	11	—	6
4	8	8	8	9	—	—	17	21	22	15	—	27	8	24	—
5	0	—	16	11	2	—	—	22	—	—	16	34	4	—	—
5A	—	—	110	12	17	—	2	22B	—	6	—	37	—	3	—
5A2	10	20	31	17	2	—	32	23	6	—	6	39	—	12	—

CRUISE S-10 (January 23-29, 1961)

Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv
U-25	7	7	7	6	23	35	17	12	12	24	36	18	97	48	42
1B	—	8	25	7	2	—	77	12B	—	24	—	18A	52	—	35
2	—	7	14	8	52	71	13	15	12	—	6	19	58	23	41
3	—	7	33	9	36	18	30	16	30	18	18	19A	4	—	16
4	14	—	—	10	12	6	24	17	25	19	6	20	6	6	—
5	26	6	32	11	—	—	32	17B	6 2	37	12	21	—	—	2

Stylocheiron longicorne

CRUISE S-2 (November 30-December 13, 1959)

Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv
9	8	--	16	11	10	50	--	14	--	--	4	17	--	3	--
10	5	5	--	13	--	2	--	16	4	14	--				

CRUISE S-4 (February 27-March 19, 1960)

Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv
2	--	--	24	8	--	--	4	15	33	16	16	20	11	--	11
3	--	--	4	9	--	16	8	16	--	--	24	21	--	--	19
4	--	75	74	10	--	--	9	17	--	51	39	24	--	--	40
5	--	--	18	11	--	4	--	18	--	--	67	26	--	--	4
6	--	45	15	12	--	--	4	19	--	--	28				

CRUISE S-6 (May 25-June 24, 1960)

Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv
2	--	--	2	8	2	--	15	16	--	6	4	23	--	28	10
3X	--	5	2	9	--	--	28	17	--	10	17	24	--	--	7
4	--	20	29	10	--	7	15	18	4	10	--	25A-X	--	--	10
5	8	10	--	11X	--	4	4	19	--	18	8	26	--	30	10
6	7	7	7	12X	3	10	5	21	2	--	15	27	--	7	28
7	--	6	20	13	--	8	14	22	--	--	15				

CRUISE S-8 (September 8-October 6, 1960)

Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv
2	--	12	10	6	42	66	8	12	4	26	17	22B	--	6	12
3	2	10	--	7	--	16	8	18	--	--	8	23	12	--	12
4	--	16	102	8	--	42	33	19	--	11	21	24	14	58	36
5	--	16	16	9	2	17	--	20	--	--	22	25	--	7	--
5A	10	40	60	10	9	46	37	21	7	30	30	26	--	40	12
5A2	--	41	41	11	8	12	10	22	--	16	--				

CRUISE S-10 (January 23-29, 1961)

Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv	Sta No	Adlt	Juv	Larv
3	3	7	13	7	--	2	--	11	--	19	26	17B	--	6	25
4	--	--	34	8	--	--	7	12	--	24	24	18	--	6	24
5	6	11	26	9	--	6	--	16	--	6	24	18A	--	--	12
6	--	--	12	10	--	12	12	17	--	--	6	19	--	6	--

Appendix IV

PRESENCE/ABSENCE OF SPECIES, 2-m NET TOWS

CRUISE	S-10	S-8	S-6	S-4	S-2	
STATIONS	203 204 205 207 208 209	203 205 206 207 208 209 210 211 212 213 214 215 216	219 217 218 215 216 213 214 211 212 210 208-209 207 206 205 202 204	220 218 219 215 217 213 214 211 212 209 210 207 208 205 206 203 204	U-50 26	
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