FAWLEY
aquatic research laboratories Ltd

Research Report

Client: FAWLEY aquatic research laboratories Ltd

Plankton samples at Hinkley Point
Nuclear Power Station,
January 1982 to December 1994

E Burfoot

For the attention of:
Dr R N Bamber

31 August 1995

FRR 179/95

1. INTRODUCTION

Zooplankton is an important part of the food web in the marine and estuarine environment. Mysids and prawns are the principle prey for many fish species within the estuary and fish such as whiting follow their prey as they migrate (Henderson & Holmes, 1989).

Over the last 14 years the zooplankton community of the Bridgewater Bay area has been regularly sampled. This has been done in conjunction with observations taken with regard to fish catches on the cooling water intake screens at the Hinkley Point Power Station which have resulted in a number of papers concerning the trophic structure of the estuary (Henderson *et al*, 1992), the factors influencing the abundance of flatfish in the lower estuary (Henderson & Seaby, 1994) and the seasonality of caridean decapod and mysid distribution (Bamber & Henderson, 1994).

2. METHODS

At Hinkley Point, the 'B' power station screens have been sampled at monthly intervals since 1981, these samples are continuing. The sampling dates are selected for tides midway between neap and spring tides (for rationale see Henderson & Holmes, 1987). The size of zooplankton requires the use of a net with a smaller mesh size than that of the screens (10mm), which are used for the collection of larger animals such as fish, shrimps and prawns. The plankton was sampled by placing two plankton nets of mesh size 700 μm and mesh size 150 μm in the intake forebay of the power station for approximately one hour per visit. This was done in the 4^{th}-5^{th} hour of sampling approximately 1-2 hours before low water. The samples obtained were fixed in 4% formalin and returned to the laboratory for sorting and identification.

Measurements of water temperature and salinity were also taken. Figure 1 shows the mean monthly values for salinity and temperature.

These samples were not quantitative as the volume of water passing through the net could not be estimated owing to the high turbulence of the forebay area. It is believed, however, that the samples currently reflect the relative abundance of the fauna present.

Animals from each of the coarse plankton samples were removed with the aid of a sieve (mesh 420 μm). Each was identified to species (where possible) and the animals were then stored collectively in 70% alcohol. Flatfish found in the samples were also identified to species and then measured using a eyepiece curtain micrometer to the nearest 0.01mm.

The fine plankton samples were treated in the same way as the coarse samples to the point of animal extraction. For the purpose of this report samples from 12 months (August 1994 - July 1995) were sorted to give an indication of community structure. The samples were sorted after rinsing with water through a 125μm sieve to retain any copepods. The presence of other species was also recorded. The number of each species of copepod in each sample was estimated through subsampling by weight.

3. OBSERVATIONS OF COARSE PLANKTON SAMPLES

The data from 1982-88 was provided by Bamber & Henderson (1994). For the period of 1986, there are no data available for the plankton. Many of the plankton samples for 1990 cannot be located. Also, there are no available records for fish in the coarse plankton before 1989.

Occasionally numbers of barnacles were contained in the samples. This is most probably due to the plankton nets turning and scraping the walls of the forebay area whilst fishing.

3.1 Number of Species

Figure 2 shows the number of species found in each of the samples. Figure 3 shows the mean number of species found each month, based on data over the sampling period Jan. 1982 - Dec. 1994 with the associated variance (two standard deviations). The total number of species found each year is shown by Figure 4. These figures do not allow for species caught more than once in a year.

There has been an increase in the number of species recorded from 1987 onwards. These numbers include the various species of fish which have been recovered from the samples. There is some temporal fluctuation due to changes in salinity and possibly water temperature. Those fluctuations due to salinity change mainly reflect seasonal migrations, as seen in the mysids and *Crangon* (described in Bamber and Henderson, 1994).

3.2 Crustacea

3.2.1 CUMACEA

3.2.1.1 Diastylis rathkei (Kröyer) (Fig.8)

This cumacean burrows shallowly into soft sediments leaving the anterior carapace and uropods exposed and may also swim up into the water column. *D. rathkei* is a northern species that occurs in the surface layers of the mud and occasionally coarser sediments. Specimens may grow up to 20mm.

This species is found in the plankton throughout the year, the peak occurring in the spring due to the recruitment of juveniles. Figure 30 shows the monthly means for *D. rathkei*. The degree of variance indicates that, in most months there is little variance from the calculated mean.

3.2.2 ISOPODA

Isopods are small dorso-ventrally flattened malacostracans lacking a carapace. The 1^{st} antennae are small, the 2^{nd} antennae conspicuous, and the eyes are unstalked. The 1^{st} pair of thoracic appendages are used as mouth parts the remainder being for locomotion. Isopods occur on the sediment surface (or more rarely in burrows in it), beneath stones or swim amongst submerged vegetation.

Eurydice pulchra Leach (Fig.9) is a predator and scavenger. It favours intertidal sediment and is found frequently in the Hinkley plankton. *Idotea baltica* (Pallas) (Fig.10) may be found living on weed and has been found on the intake screens on occasion. *Idotea granulosa* Rathke (Fig.11), has been found rarely on the screens and only in two plankton samples. Both *I. baltica* and *I. granulosa* occur amongst fucoid and other macroalgae which they consume when they start to decay.

Figure 31 shows the mean monthly values for *Eurydice*. It can be seen that the number of individuals from month to month is very variable.

To find these creatures in the plankton may be unusual, however, owing to the turbidity of the area, nothing is unusual.

3.2.3 AMPHIPODA

Amphipods are small malocastracans lacking a carapace which are flattened laterally. The first and second antennae are variously developed and the eyes are not stalked. The first pair of thoracic appendages (gnathopods) are usually subchelate. The abdomen bears three pairs of jumping legs, three pairs for swimming and a telson which may be degenerate. These animals may be found in burrows in the sediment, in tubes on vegetation, beneath stones and algae or amongst submerged plants.

3.2.3.1 Corophium volutator Pallas (Fig.12)

Corophium is relatively easy to distinguish from other amphipods by virtue of the 2^{nd} antennae being well developed and as long as the body. This species is benthic, living in U-shaped burrows and grazes on sediment using the 2^{nd} antennae to scrape the surface of the mud. The species tolerates a wide range of salinities from near fully saline to almost fresh water. Distribution from North Atlantic, American and European coasts from western Norway to Mediterranean, Black Sea and the Azov Sea. It has been postulated that individuals found within the sample have been taken from a population living in the power station culvert.

The monthly means Fig.32 are consistant throughout the year with little variance.

3.2.3.2 ***Gammarellus homari*** **(Fabricius) (Fig.13)**

A subtidal species, occasionally found intertidally at extreme low water. The distribution of this species is North Atlantic and Arctic Ocean, widespread; American and European coasts; North Sea.

G. homari is present in the plankton throughout the year. There are peaks in the spring most probably due to juvenile recruitment. This increase can also be seen in the monthly means (Fig. 33). However, there is a lot of variation around the means.

3.2.3.3 ***Bathyporeia pelagica*** **(Bate) (Fig.14)**

Bathyporeia can more usually be found on the lower to middle shore burrowing in sand and growing to a length up to 6mm. The species has not been recorded outside the British Isles (Lincoln, 1979). This amphipod is rare in the plankton, the greatest number (4) being collected in the spring 1993. The appearance of *B. pelagica* occurs in the late spring.

3.2.3.4 ***Gammarus salinus*** **Spooner (Fig.15)**

Length up to 22mm (male), 17mm (female). Distribution: north-west Europe from the English Channel to the Baltic. Present in small numbers throughout the sample period with peaks in the spring samples. There is a rather large number in the early part of 1994. There is minimal variance around the monthly means for *G. salinus* (Fig.34).

*3.2.3.5 **Jassa pusilla (Sars) (Fig.16)***

Length up to 5mm, colour varigated with brown. Gnathopod 2 (male) palmar process small and simple in small individuals; larger individuals palmar process longer, rectangular with weakly bilobed apex. Depth range about 20-200m, often associated with hydroid growths or amongst sponges. Distribution north-east Atlantic, North Sea, European coasts from northern Norway to west coast of France. Around the Britsih Isles this species has been recorded from the Wash, West Channel, Bristol Channel and the Isle of Man.

Peak numbers of this species arise in mid-summer. These amphipods have been found in larger numbers in more samples over recent years. Like *Corophium*, *Jassa* is a culvert dweller.

3.2.3.6 ***Parajassa pelagica*** **(Leach) (Fig.17)**

Length of up to 9mm, colour greyish with transverse brown banding. Depth range from lower intertidal to 50m, builds nests amongst algae, hydroids and other growths. Locally common or even abundant. Distributed in the Arctic Ocean, North East Atlantic, North Sea and European coasts from northern Norway to Portugal.

This species of amphipod has been in evidence since 1989. Since this time there has been a major peak in abundance in the Autumn 1991.

3.2.3.7 ***Calliopius laeviusculus*** **(Kröyer) (Fig.18)**

The depth range for this species is from intertidal to 20m, and usually found amongst algae on rocky shores, locally numerous on sheltered or moderately exposed shores. The distribution being Circumpolar, acrtic-boreal; Arctic Ocean; North Atlantic; American and European coastsfrom northern Norway to north-west France. In the extreme west of the region *Calliopius* can occur in salinities of 6%.. Prior to 1986, this amphipod had only been recorded in one sample (in this dataset). Since 1987, the species has become more frequent albeit in relatively small numbers.

3.2.3.8 ***Atylus swammerdami*** **(Milne-Edwards) (Fig.19)**

A ubiquitous and locally common species amongst vegetation, especially over a sandy substratum with the depth range from lower intertidal to 50m. Individuals may grow to approximately 10mm. Distribution is from North Atlantic, American and European coasts from northern Norway to the western Mediterranean and the Arctic Ocean.

Due to the small number of individuals collected, it is difficult to comment on the temporal distribution of this species. This species had not been recorded in this dataset before 1989.

3.2.3.9 Caprella linearis (L.) (Fig.20*)*

This amphipod has a long, thin body with a reduced abdomen and the vestige of a telson. Its habitat is amongst hydroids on the lower shore downwards, sometimes swimming.

This species has been in the samples on a few occasions, the greatest numbers being in mid summer. The individuals in the sample from July 1993 were clustered together, many of them were small individuals.

3.2.4 MYSIDACEA

The mysids are small, swimming malacostracans which rarely reach more than 3cm in length. They possess a thin carapace and an abdomen of six segments. The thoracic appendages are simple and the abdominal appendages are short. The telson and uropods form a fan and are useful in species identification. The eyes are conspicuous and are carried on movable eyestalks. *In vivo* these animals are transparent and may remain suspended in the water column through swimming movements. Females often carry a brood pouch on the ventral surfaces.

3.2.4.1 *Gastrosaccus spinifer* (Goes) (Fig.21)

A widely distributed and common, bottom-dwelling species that can extend into estuaries. It occurs in dense swarms, including in *Zostera* meadows, and is often found partially buried in the sediment. Specimens may grow up to 20mm long. *G. spinifer* may be easily distinguished from other mysids by virtue of a spine on the dorsal surface of the 5th abdominal segment. This species occurs throughout the year in the plankton, numbers peaking in the spring and autumn. The means in March, November and December show little variance (Fig 35).

3.2.4.2 Mesopodopsis slabberi (van Beneden) (Fig.22*)*

An abundant and characteristic estuarine mysid. It has been recorded in virtually all northwest European estuaries (Barnes, 1994). Apart from the eyes which protrude on stalks beyond the carapace, the animal is completely transparent. Found abundantly in the summer months and nominally represented in the winter. Out of all the months, April and October show the least variance in mean (Fig. 36).

3.2.4.3 *Schistomysis spiritus* (Norman) (Fig.23)

The most common mysid overall found abundantly in the plankton. Peak numbers occur in the autumn with the recruitment of juveniles. Numbers reduced in the winter due to reduction in salinity causing the displacement of the population. Monthly means for this species are shown in Figure 37. There is little variance around the mean in the winter months. Over the year there is an increase in the mean number of *S. spiritus* being recorded in the samples.

3.2.4.4 Schistomysis kervillei (Sars) (Fig.24)

A relatively rare species known from the southern shore of the Channel and North Sea northwards to Scotland, that has been found in the Hinkley samples on occasion.

3.2.4.5 *Praunus flexuosus* (Müller) (Fig.25)

The habitat of *P. flexuosus* is in pools on the lower shore and in shallow water, especially among *Zostera* beds over sandy substrates. The largest of all mysids with a length up to 25mm, is found in the plankton at Hinkley through the year, with peak numbers being attained in the early spring (March). This species favours low salinity and was previously only caught in winter at Hinkley (Bamber & Henderson, 1994). Numbers are not in the same order as those of other mysid species. Although this species is caught in small numbers in the summer, the variance around the means is small (Fig. 38).

3.2.4.6 *Neomysis integer* (Leach) (Fig.26)

The habitat of *Neomysis* is often in shallow water where the salinity is reduced, e.g. estuaries and lagoons. This mysid has not occurred in the samples as often as other mysids. It is difficult to comment on its abundance in the plankton.

3.2.5 DECAPODA

Caridea

3.2.5.1 *Crangon crangon* (L.) (Fig.27)

From the coarse samples juveniles and some adults were isolated. The peak of numbers occurs around mid-summer. This illustrates the recruitment of juveniles from the winter spawning and is opposite to the trends observed by Bamber & Henderson (1994), where peak numbers were observed in winter. [These numbers included individuals collected from the main intake screen samples.] The monthly means for *Crangon* are shown in Figure 39. There is a peak in the mean numbers in the early summer which accounts for juvenile recruitment. The variance around the mean for June is also the greatest which indicates that there is a great deal of variation in recruitment from year to year.

3.2.5.2 *Pasiphaea sivado* (Risso) (Fig.28)

A western species absent from the Channel and North Sea that penetrates the brackish waters of the larger estuaries. Specimens may grow up to 100mm. A few individuals were found in the coarse samples, *P. sivado* is more abundant on the screens in summer.

3.2.5.3 *Palaemon serratus* (Pennant) (Fig.29*)*

The rostrum of *P. serratus* is pronounced with teeth on both dorsal and ventral edges with an upturned end. The gnathopods are chelate. These animals grow up to 110mm and are the least brackish-water of the regions palaemonids. This species has been found abundantly on the screens. There has been only one record from the plankton sample.

Brachyura

The megalopa stages of *Corystes cassilvelaunus* (Pennant), *Carcinus maenas* (L.) and *Cancer pagurus* L., have been found in several of the coarse plankton samples for the months of May-July. More developed stages of *C. maenas* and *Liocarcinus sp.* have also been found in late summer.

4. FINE PLANKTON SAMPLES

4.1 Copepods (Figure 45)

The main species of copepod encountered in the fine samples were: *Eurytemora bifilosa, Centropages hamatus, Calanus helgolandicus* & *Acartia spp.* These species have been studied in greater detail by Collins & Williams (1981) and may be classed according to their tolerance of salinity.

Of all the four species, *Acartia spp.* are the most dominant throughout the year. There are three main peaks, in October, February and in June, June being the greatest. *Acartia spp.* have been classed as estuarine-marine species with a tolerance between 27 and 33 ‰. All of the copepod species peaked during the same periods most probably due to the availability of phytoplankton.

5. FISH (COARSE & FINE SAMPLES)

5.1.1.1 Goby spp. (Figure 40)

Post larval and adult individuals were collected in the coarse sample. As yet these have not been identified to species. The specimens collected mainly fall into the sand goby complex, however, the presence of transparent and crystal gobies has been noted. There is a peak in numbers in the June samples.

5.1.1.2 *Anguilla anguilla* (L.) (Figure 41)

Eels first enter estuaries and lagoons connected to the sea as 70mm long, transparent elvers ('glass eels') between January and April. Many pass straight through the brackish zones and enter freshwater. Elvers have been present in within the sample during late winter/early spring corresponding with the annual migration of elvers up the river from the sea. The elvers have appeared only in small numbers (max. 4).

5.1.1.3 Flatfish post larvae (Figures 42-44)

There are two distinct months where the post larvae have appeared, April and May with the peak occurring in April. In June 1994 & 1995 some flounder postlarvae were captured. All of the fish were in various stages of metamorphosis.

The individuals taken in the coarse samples are mainly flounder (*Platicthys flesus*) post-larvae. There is a full range of sizes recorded from all of the months where flounder were present. In 1990-3 the earliest appearence of flounder was in April. In 1994-5 the earliest recording of flounder was in May, this may be an indication of a change in environmental conditions affecting the hatching of eggs.

There are a few sole (*Solea solea*) all in settlement stages. These individuals have been found in all months, the most in May 1990. All of the individuals found were of a size greater than 6.01mm in length.

Plaice (*Pleuronectes platessa*) have been captured in the plankton nets on a few occasions in very small numbers (max. 2). These have been in the settlement stage with a size range of greater than 9.5mm.

Other fish species which have been collected in the plankton samples include:

Merlangius merlangus (L.)
Pholis gunnellus (L.)
Sprattus sprattus (L.)
Ammodytes sp.
Callionymus sp.

These species have appeared occasionally in the coarse plankton samples. However, they are more frequently represented in the screen samples.

6. OTHER SPECIES

6.1 Pycnogonida

On a few occasions organisms which are not planktonic have appeared in the samples. Of these, the most amazing creatures are the Sea-spiders.

4/89	*Nymphon brevirostre* Hodge 1863
20/7/92	*Anoplodactylus pygmaeus* (Hodge 1864)
11/2/93	*Pycnogonum littorale* (Ström 1762)

7. REFERENCES

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SPECIES LIST

AMPHIPODA	*Corophium volutator*
	Atylus swammerdami
	Calliopius laeviusculus
	Gamarellus homeri
	Bathyporeia pelagica
	Dyopedos monacanthus
	Gammarus salinus
	G. oceanicus
	G. duebeni
	Pseudoprotella phasma
	Jassa pusilla
	Parajassa pelagica
	Caprella linearis
	Caprella sp.
ISOPODA	*Eurydice pulchra*
	Sphaeroma monodi
	Idotea baltica
	I. granulosa
CUMACEA	*Diastylis rathkei*
	Cumopsis goodsiri
MYSIDACEA	*Schistomysis spiritus*
	S. kervillei
	Gastrosaccus spinifer
	Mesopodopsis slabberi
	Praunus flexuosus
	Neomysis integer
	Anchialina agilis
	Paramysis arenosa
CARIDEA	*Crangon crangon*
	Pasiphaea sivado
	Palaemon serratus
BRACHYURA	*Corystes cassivelaunus*
	Carcinus maenas
	Cancer pagurus
PISCES	Goby spp.
	Flatfish spp.
	Merlangius merlangus
	Anguilla anguilla
	Ammodytes sp.
	Callionymus sp.
	Sprattus sprattus

Pholis gunnellus

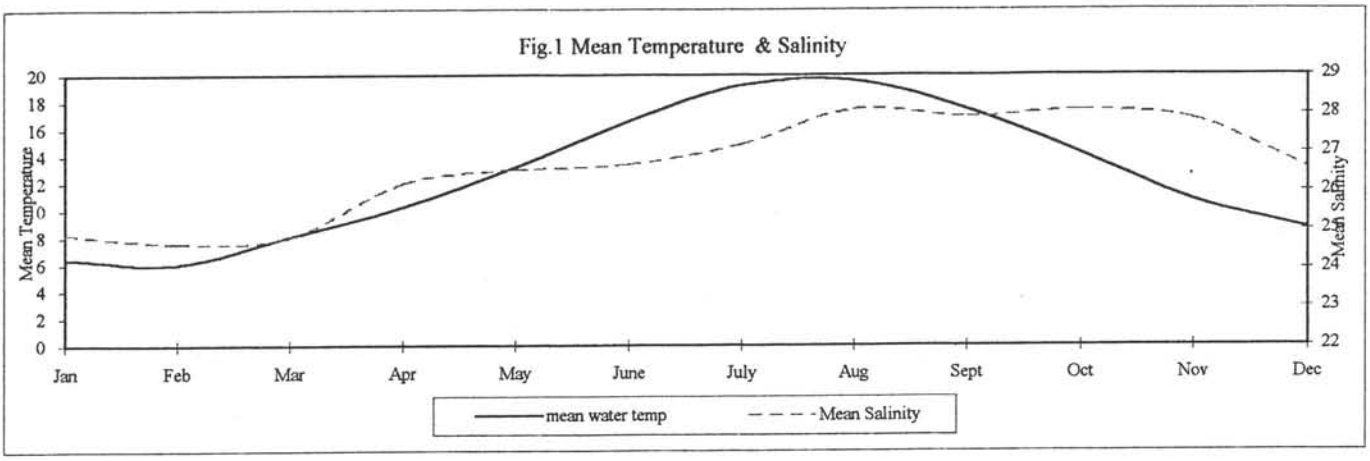


Fig.1 Mean Temperature & Salinity
Mean Temperature
Mean Salinity
Jan
Feb
Mar
Apr
May
June
July
Aug
Sept
Oct
Nov
Dec
mean water temp
Mean Salinity

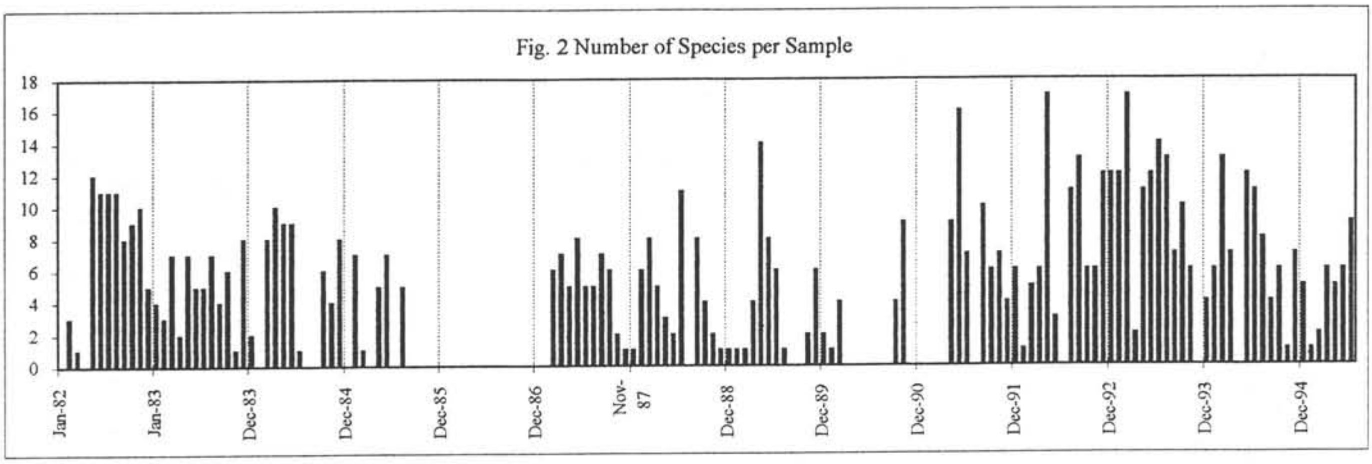


Fig. 2 Number of Species per Sample
Jan-82
Jan-83
Dec-83
Dec-84
Dec-85
Dec-86
Nov-87
Dec-88
Dec-89
Dec-90
Dec-91
Dec-92
Dec-93
Dec-94

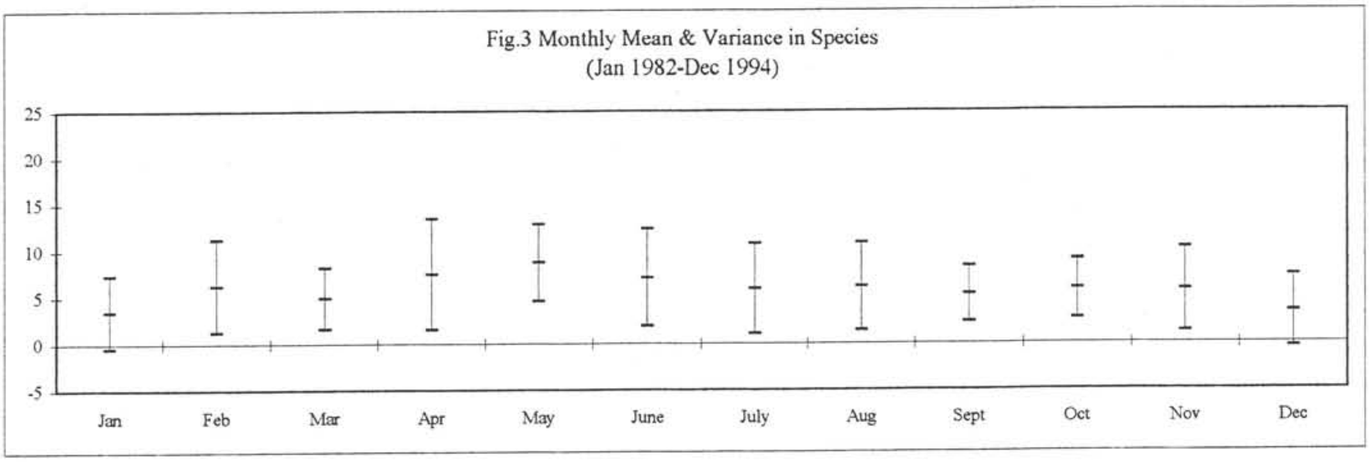


Fig.3 Monthly Mean & Variance in Species
(Jan 1982-Dec 1994)
Jan
Feb
Mar
Apr
May
June
July
Aug
Sept
Oct
Nov
Dec

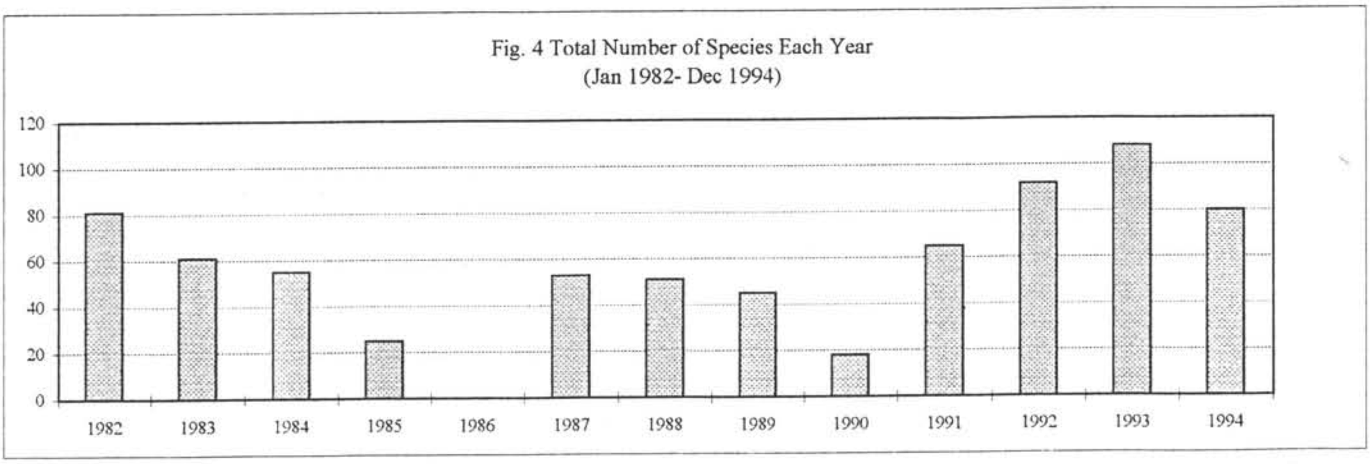


Fig. 4 Total Number of Species Each Year
(Jan 1982- Dec 1994)
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994

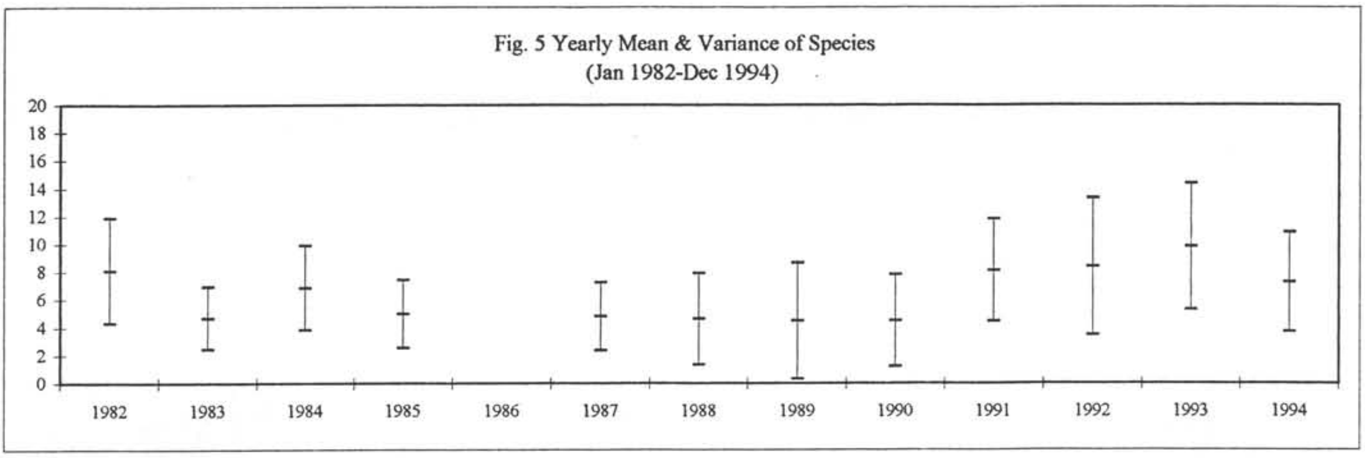


Fig. 5 Yearly Mean & Variance of Species
(Jan 1982-Dec 1994)
20
18
16
14
12
10
8
6
4
2
0
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994

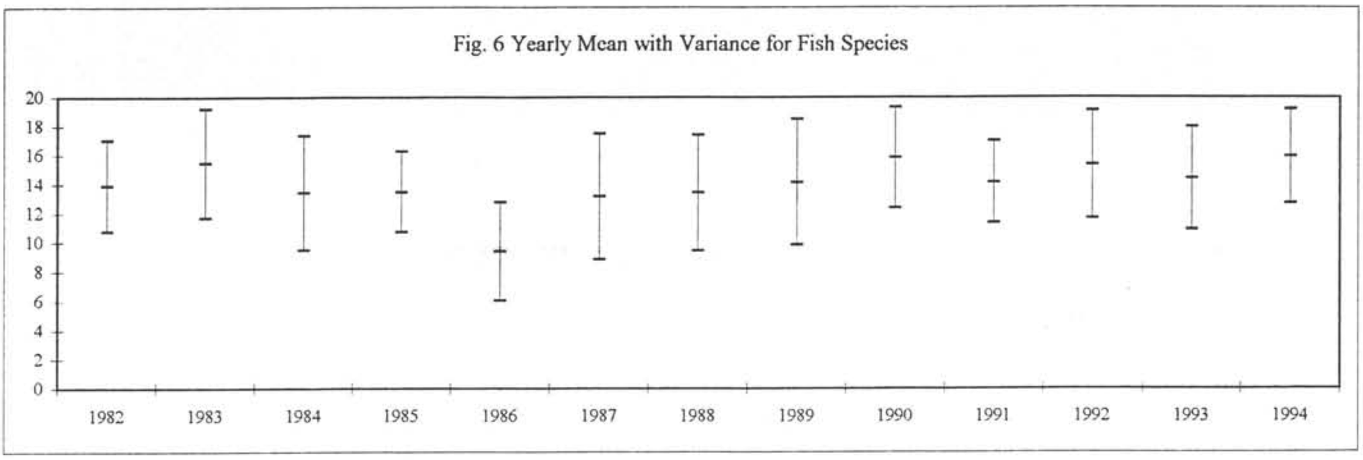


Fig. 6 Yearly Mean with Variance for Fish Species
20
18
16
14
12
10
8
6
4
2
0
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994

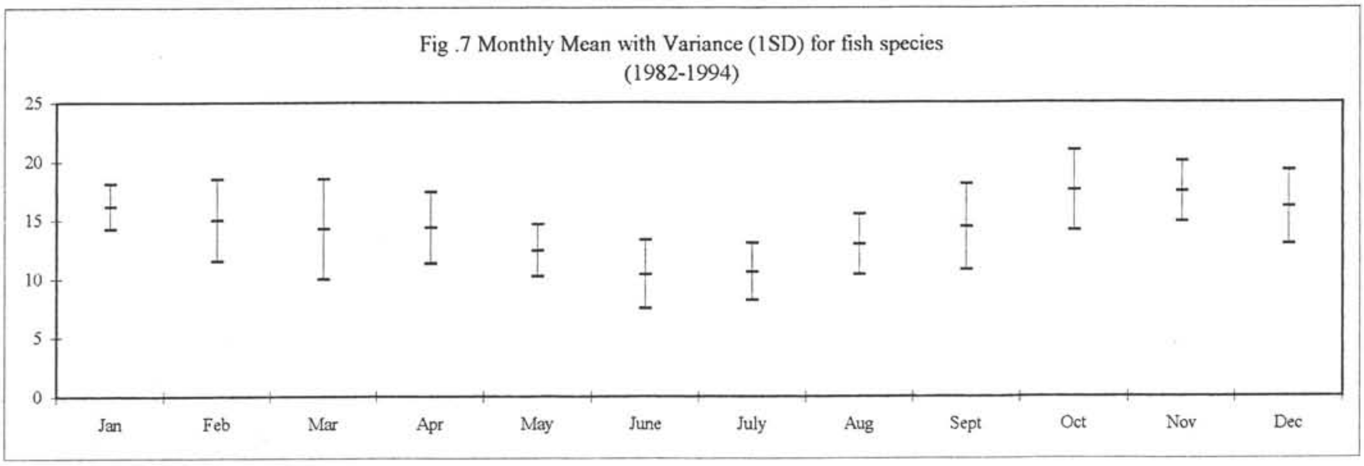


Fig .7 Monthly Mean with Variance (1SD) for fish species
(1982-1994)
25
20
15
10
5
0
Jan
Feb
Mar
Apr
May
June
July
Aug
Sept
Oct
Nov
Dec

Fig. 8 *Diastylis rathkei*

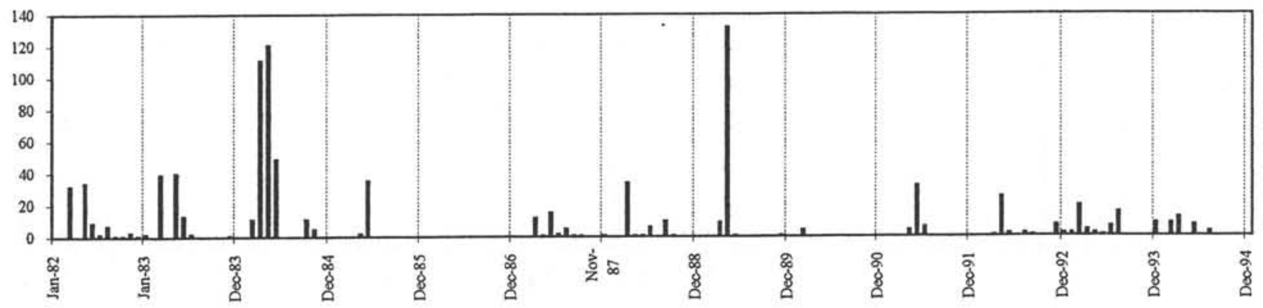


Fig.9 *Eurydice pulchra*

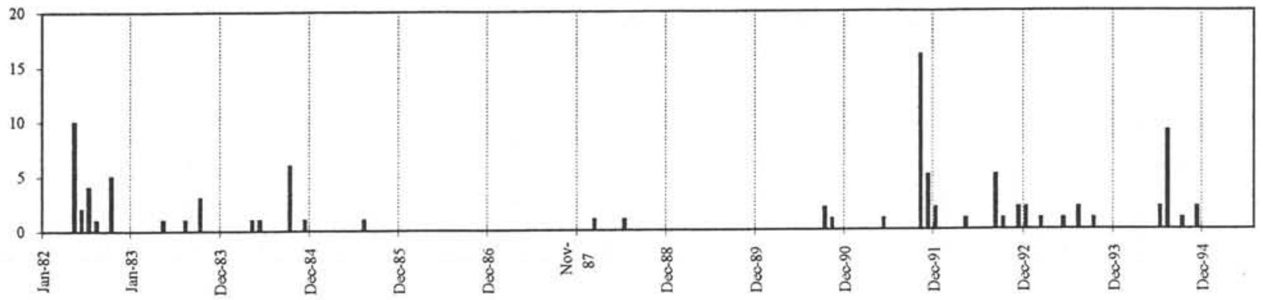


Fig. 10 *Idotea baltica*

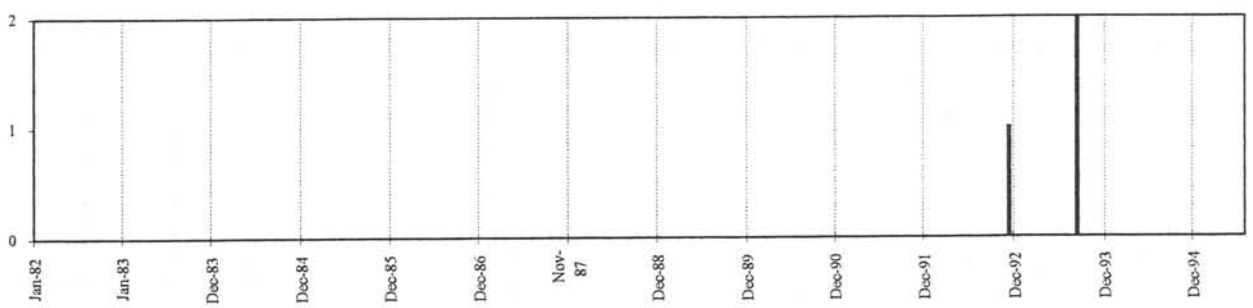
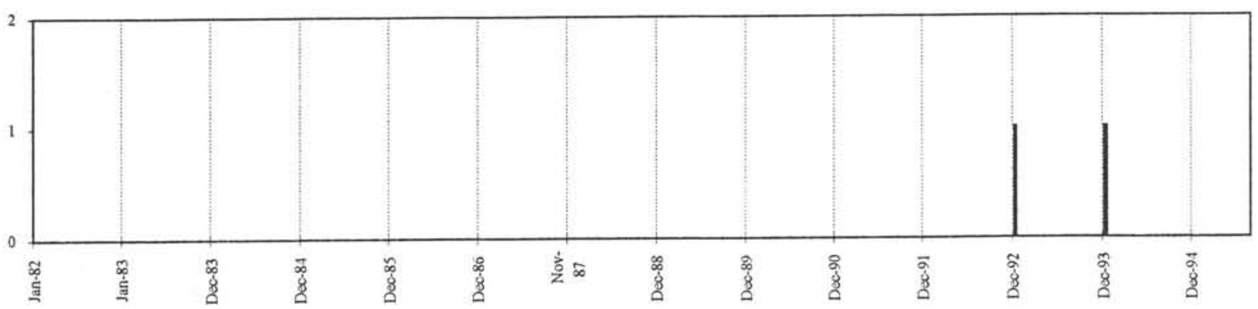


Fig. 11 *Idotea granulosa*



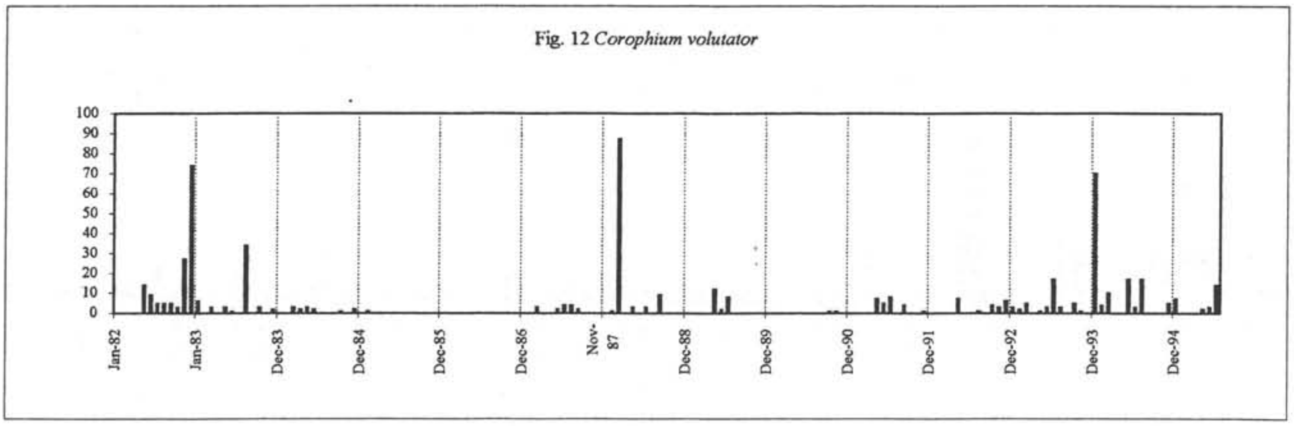


Fig. 12 Corophium volutator
100
90
80
70
60
50
40
30
20
10
0
Jan-82
Jan-83
Dec-83
Dec-84
Dec-85
Dec-86
Nov-87
Dec-88
Dec-89
Dec-90
Dec-91
Dec-92
Dec-93
Dec-94

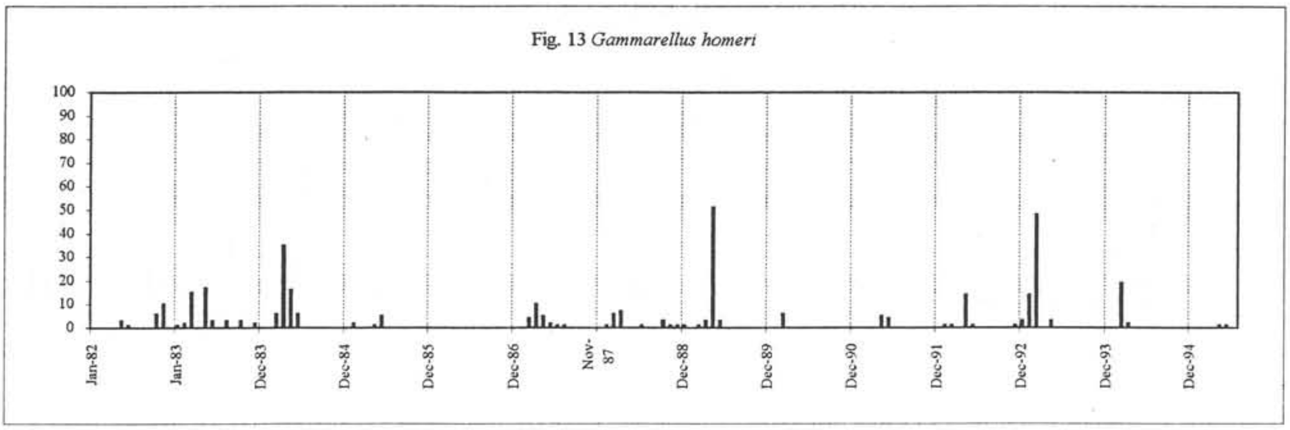


Fig. 13 Gammarellus homeri
100
90
80
70
60
50
40
30
20
10
0
Jan-82
Jan-83
Dec-83
Dec-84
Dec-85
Dec-86
Nov-87
Dec-88
Dec-89
Dec-90
Dec-91
Dec-92
Dec-93
Dec-94

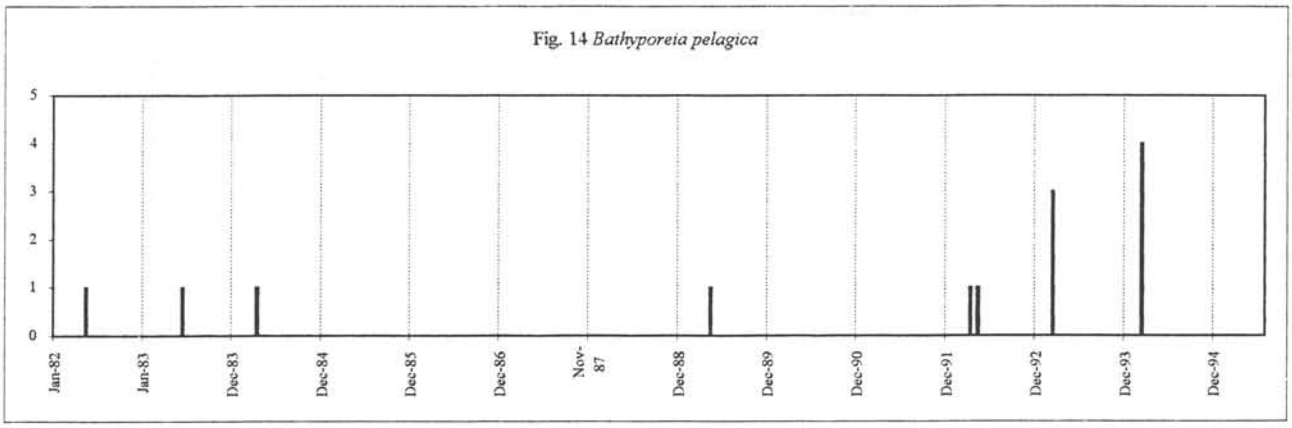


Fig. 14 Bathyporeia pelagica
5
4
3
2
1
0
Jan-82
Jan-83
Dec-83
Dec-84
Dec-85
Dec-86
Nov-87
Dec-88
Dec-89
Dec-90
Dec-91
Dec-92
Dec-93
Dec-94

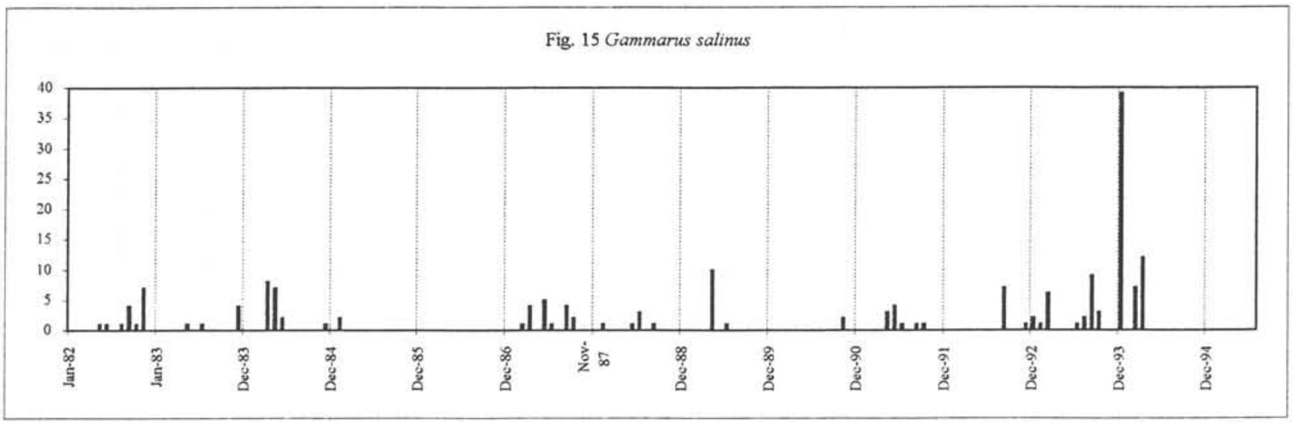


Fig. 15 Gammarus salinus
40
35
30
25
20
15
10
5
0
Jan-82
Jan-83
Dec-83
Dec-84
Dec-85
Dec-86
Nov-87
Dec-88
Dec-89
Dec-90
Dec-91
Dec-92
Dec-93
Dec-94

Fig. 16 *Jassa pusilla*

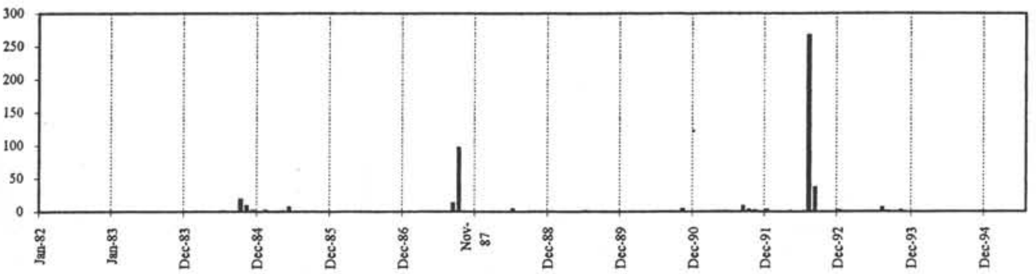


Fig. 17 *Parajassa pelagica*

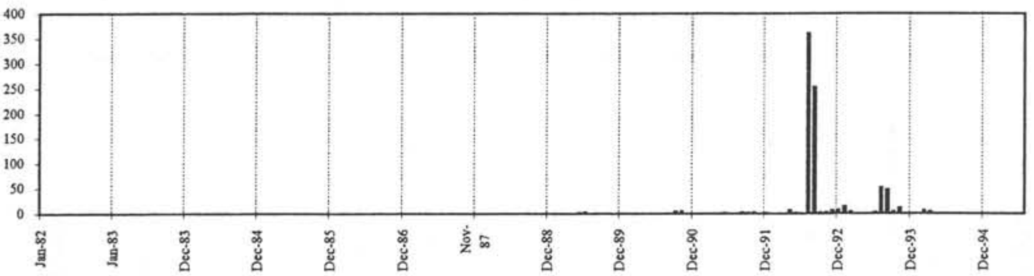


Fig. 18 *Calliopius laeviusculus*

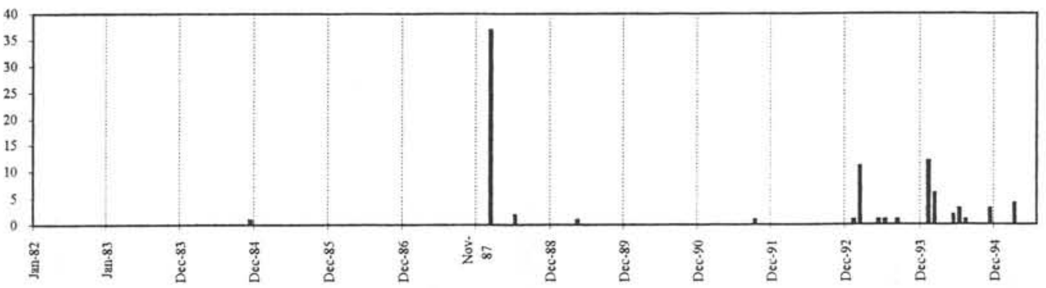


Fig. 19 *Atylus swammerdami*

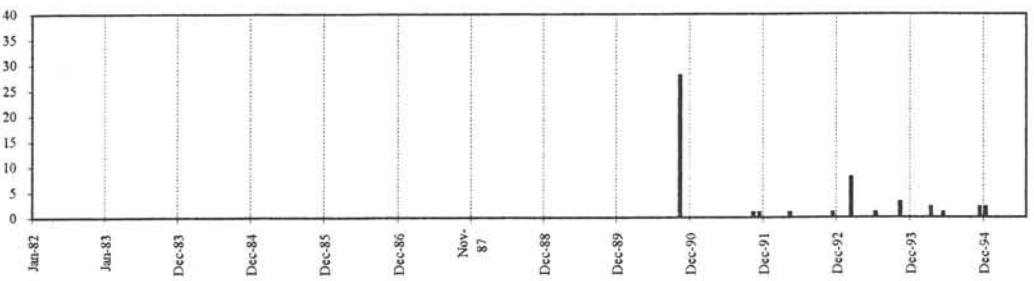


Fig.20 *Caprella linearis*

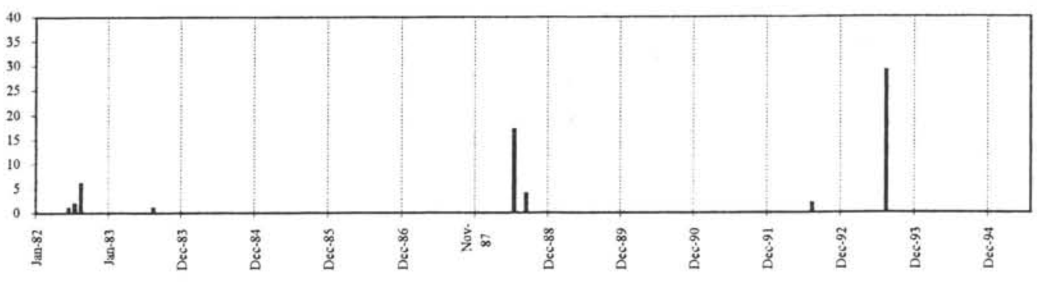


Fig. 21 *Gastrosaccus spinifer*

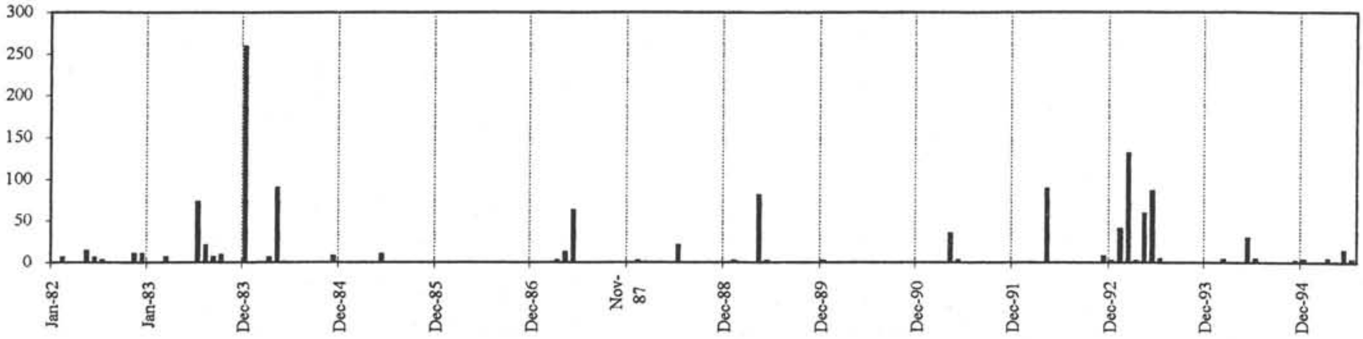


Fig. 22 *Mesopodopsis slabberi*

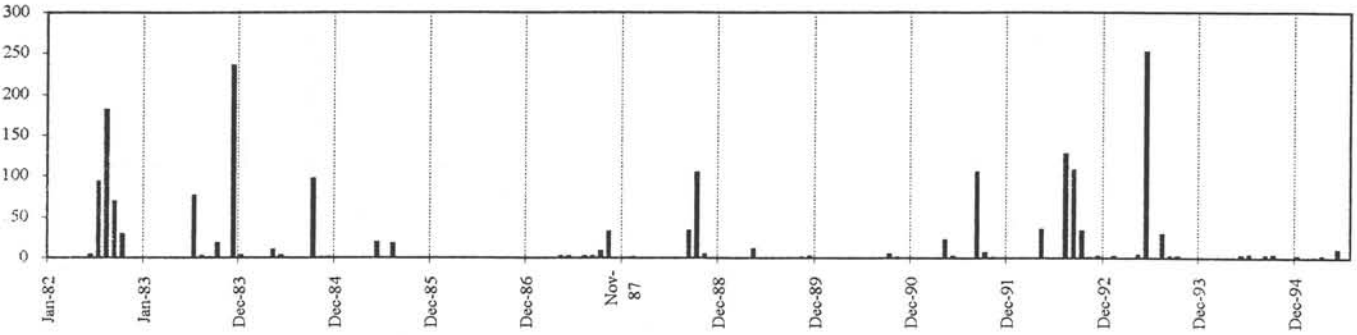


Fig. 23 *Schistomysis spiritus*

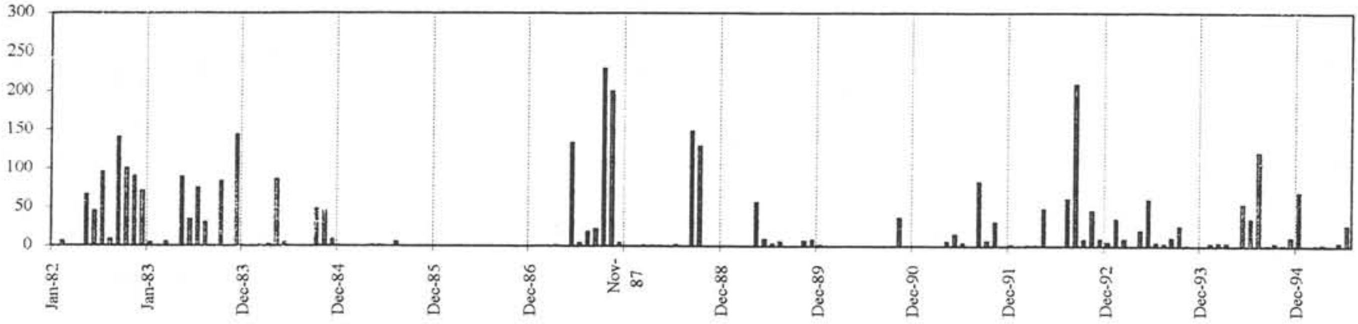
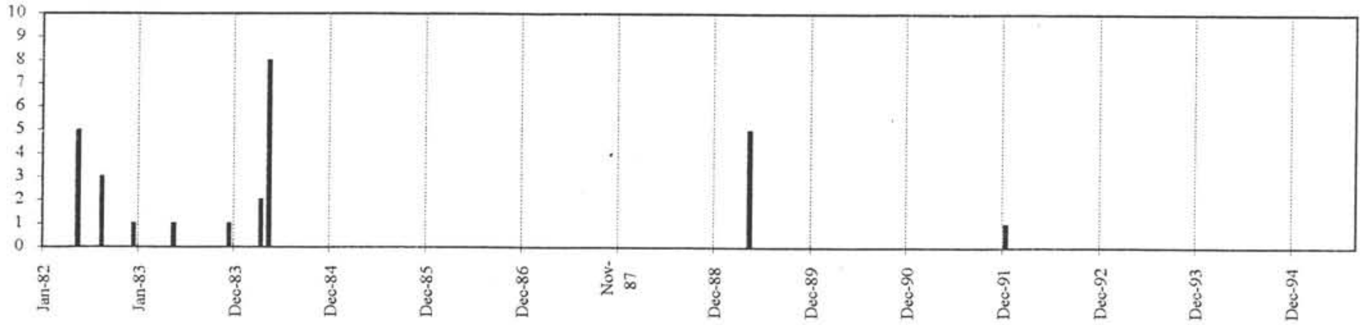


Fig. 24 *Schistomysis kervellei*



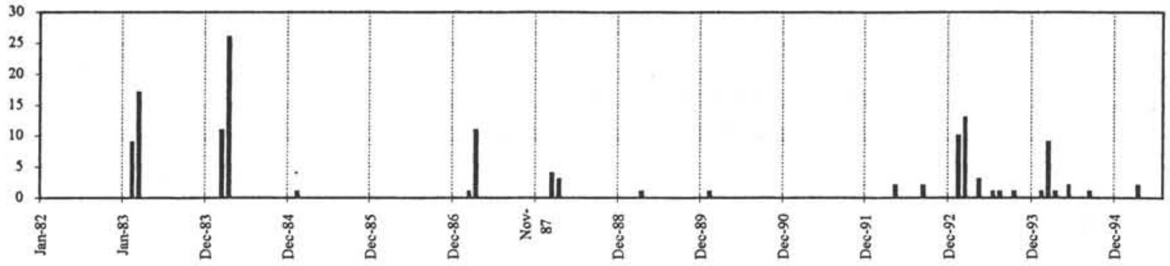


Fig. 25 *Praunus flexuosus*

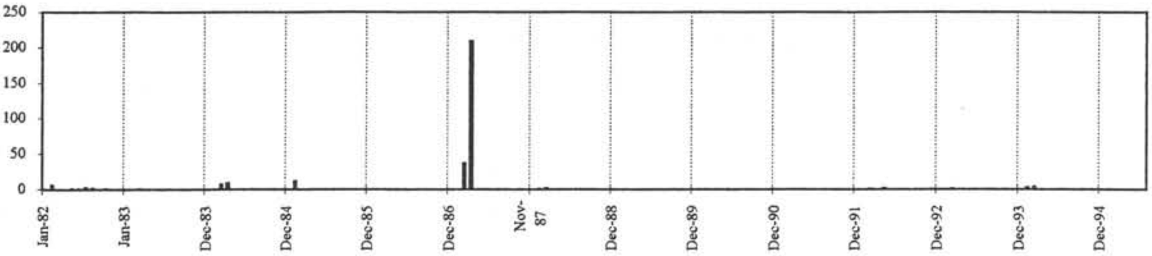


Fig. 26 *Neomysis integer*

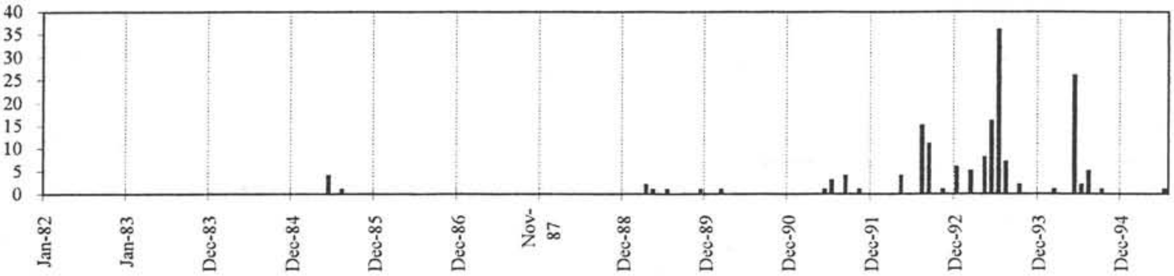


Fig. 27 *Crangon crangon*

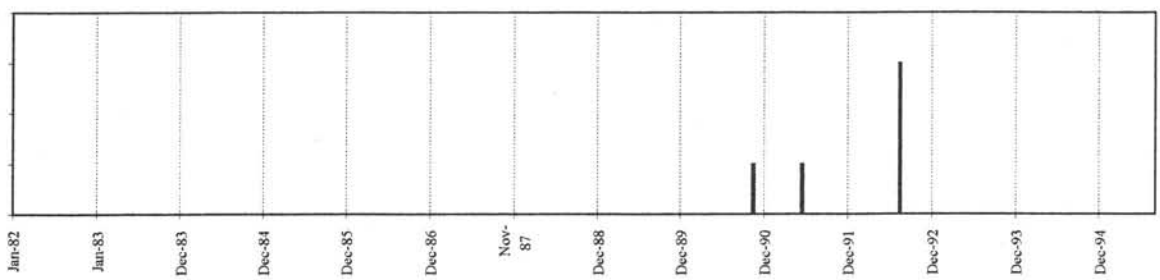


Fig. 28 *Pasiphaea sivado*

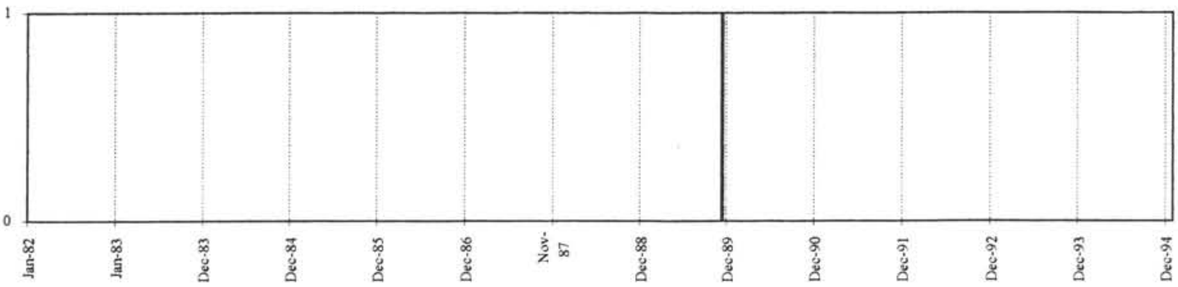


Fig. 29 *Palaemon serratus*

Fig. 30 Monthly Means with Variance for *Diastylis rathkei*

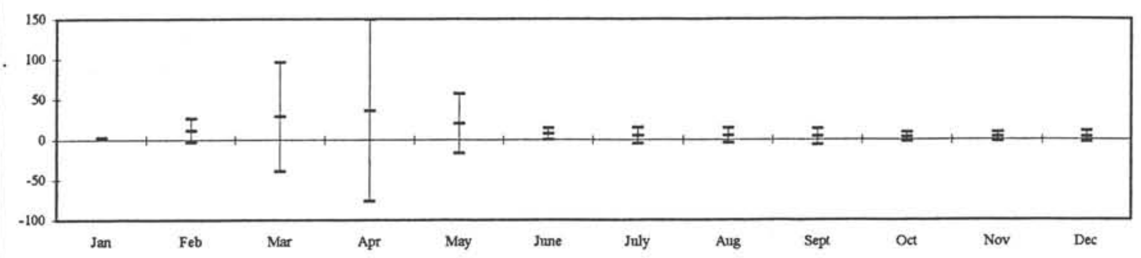


Fig. 31 Monthly Mean with Variance for *Eurydice pulchra*

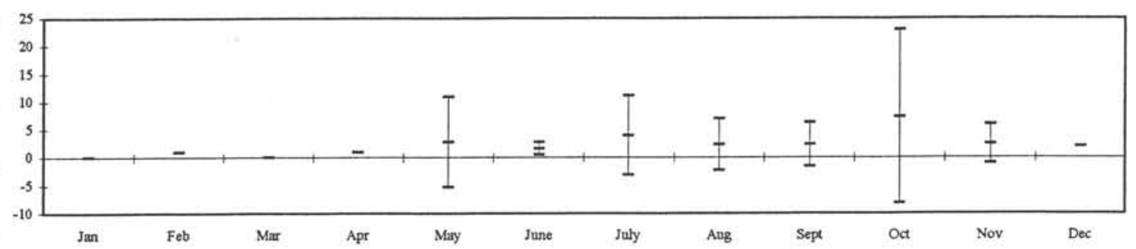


Fig. 32 Monthly Means With Variance for *C. volutator*

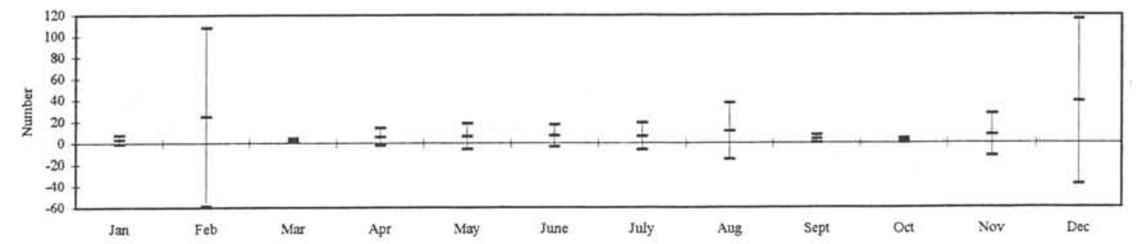


Fig. 33 Monthly Mean with Variance for *Gammarellus homeri*

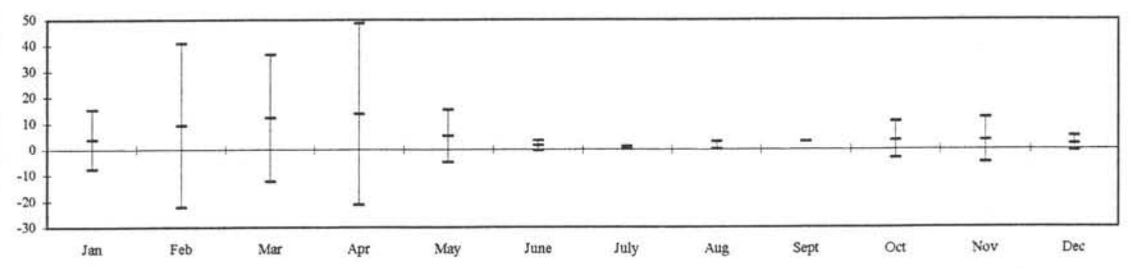


Fig. 34 Monthly Mean with Variance for *Gammarus salinus*

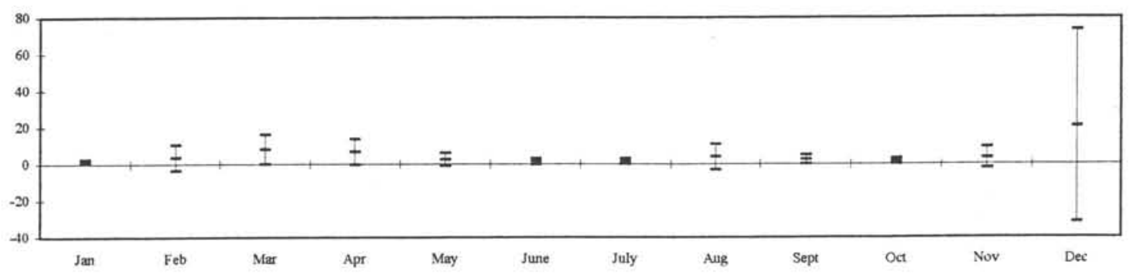


Fig. 35 Monthly Mean with Variance for *Gastrosaccus spinifer*

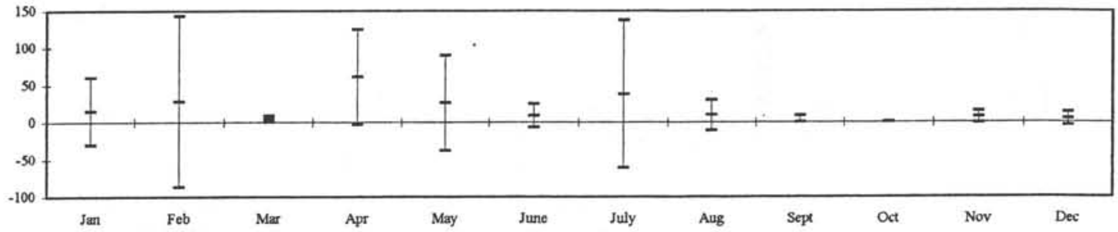


Fig. 36 Monthly Mean with Variance for *Mesopodopsis slabberi*

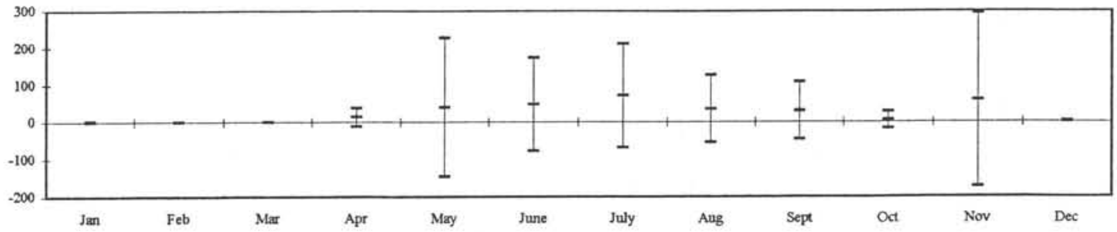


Fig. 37 Monthly Mean with Variance for *S. spiritus*

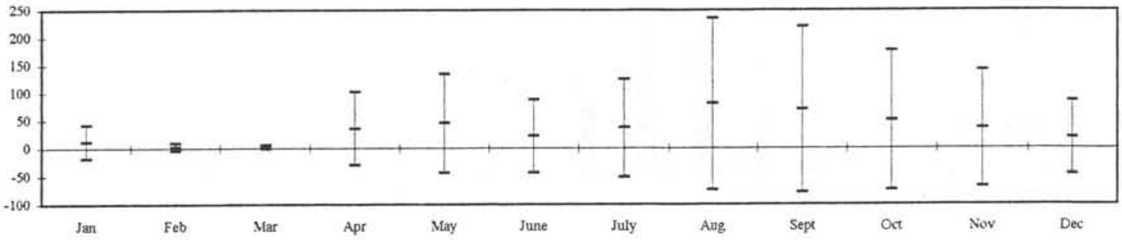


Fig 38 Monthly Mean with Variance for *Praunus flexuosus*

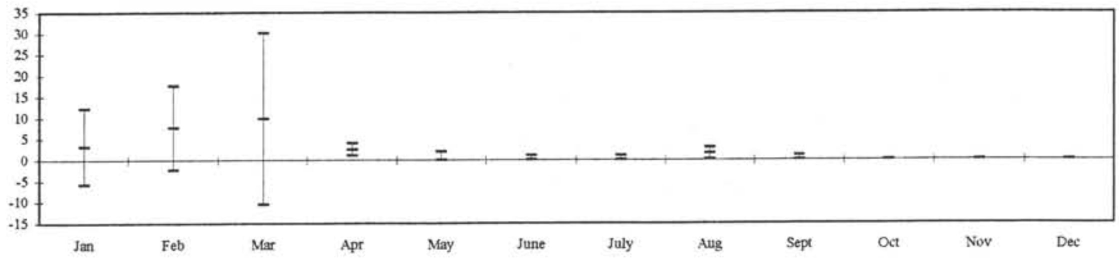


Fig. 39 Monthly Mean with Variance for *Crangon crangon*

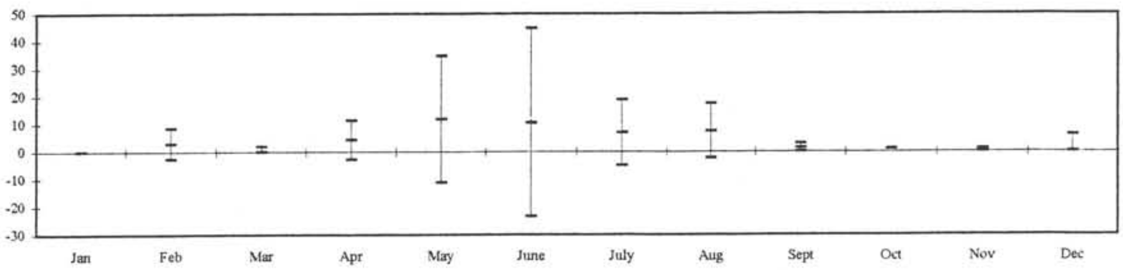


Figure 42: Size-Frequency of *Platichys flesus*

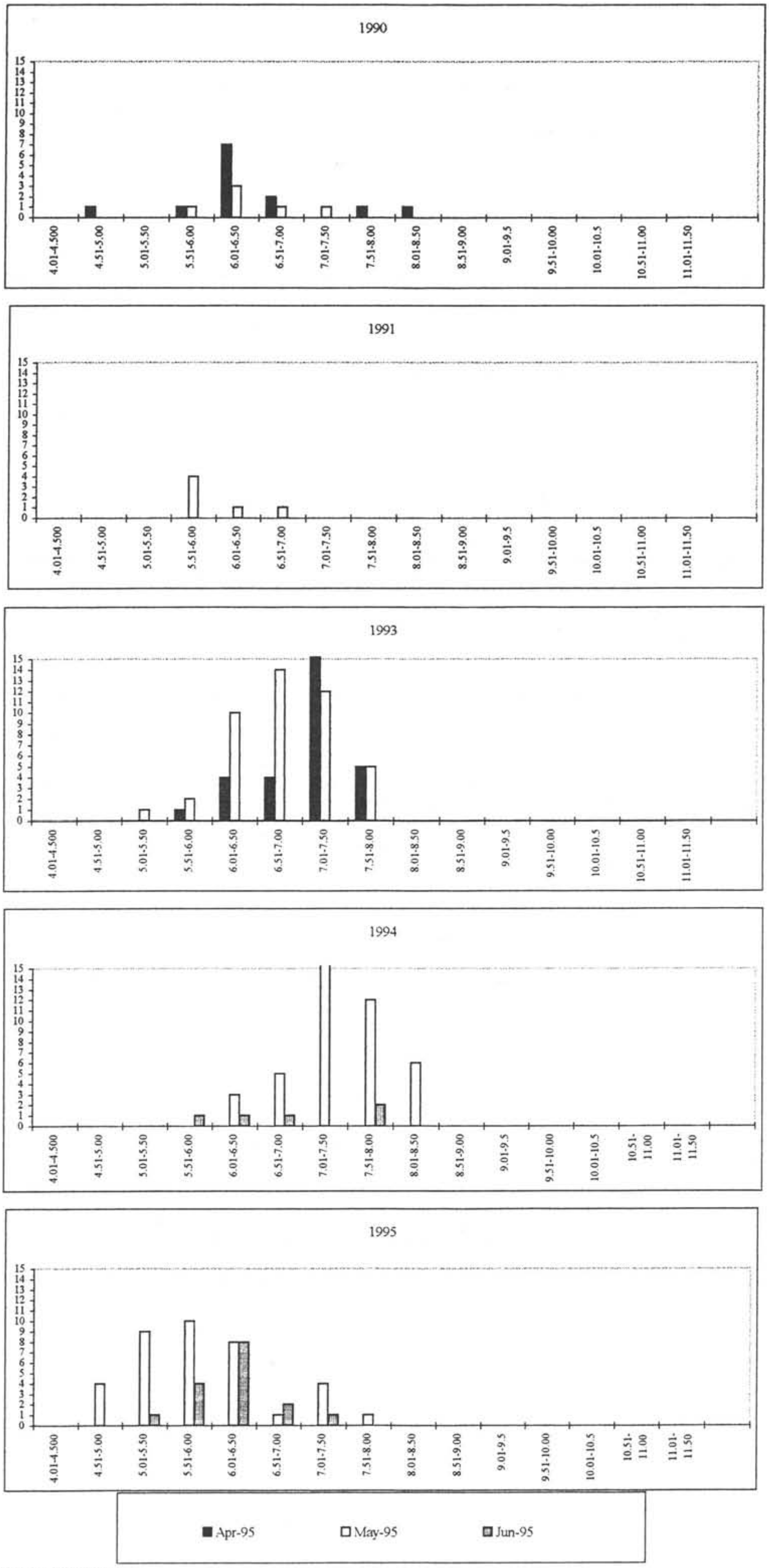


Figure 43: Size-Frequency of *Pleuronectes platessa*

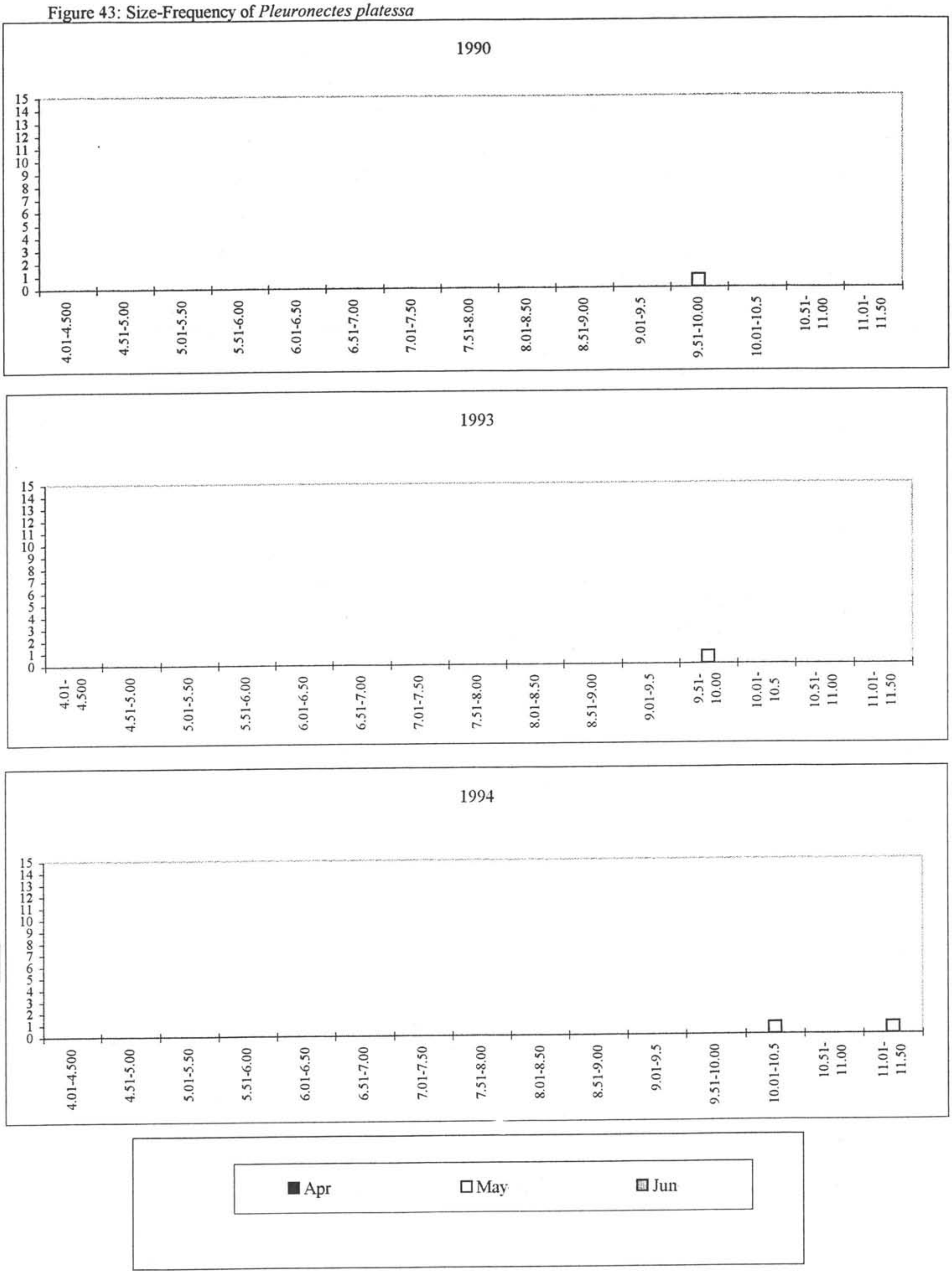


Figure 44: Size-Frequency of *Solea solea*

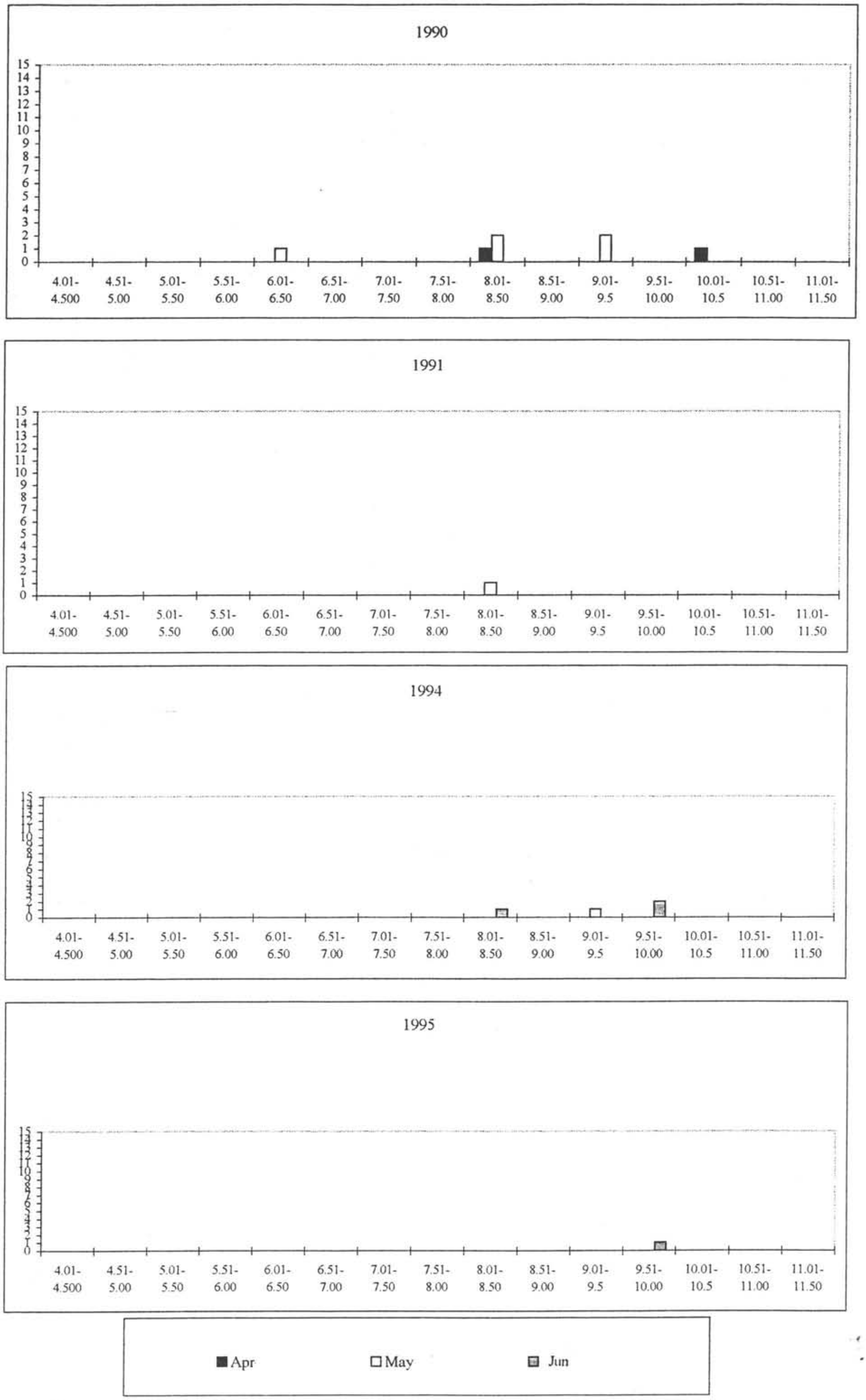


Figure 45 Copepods