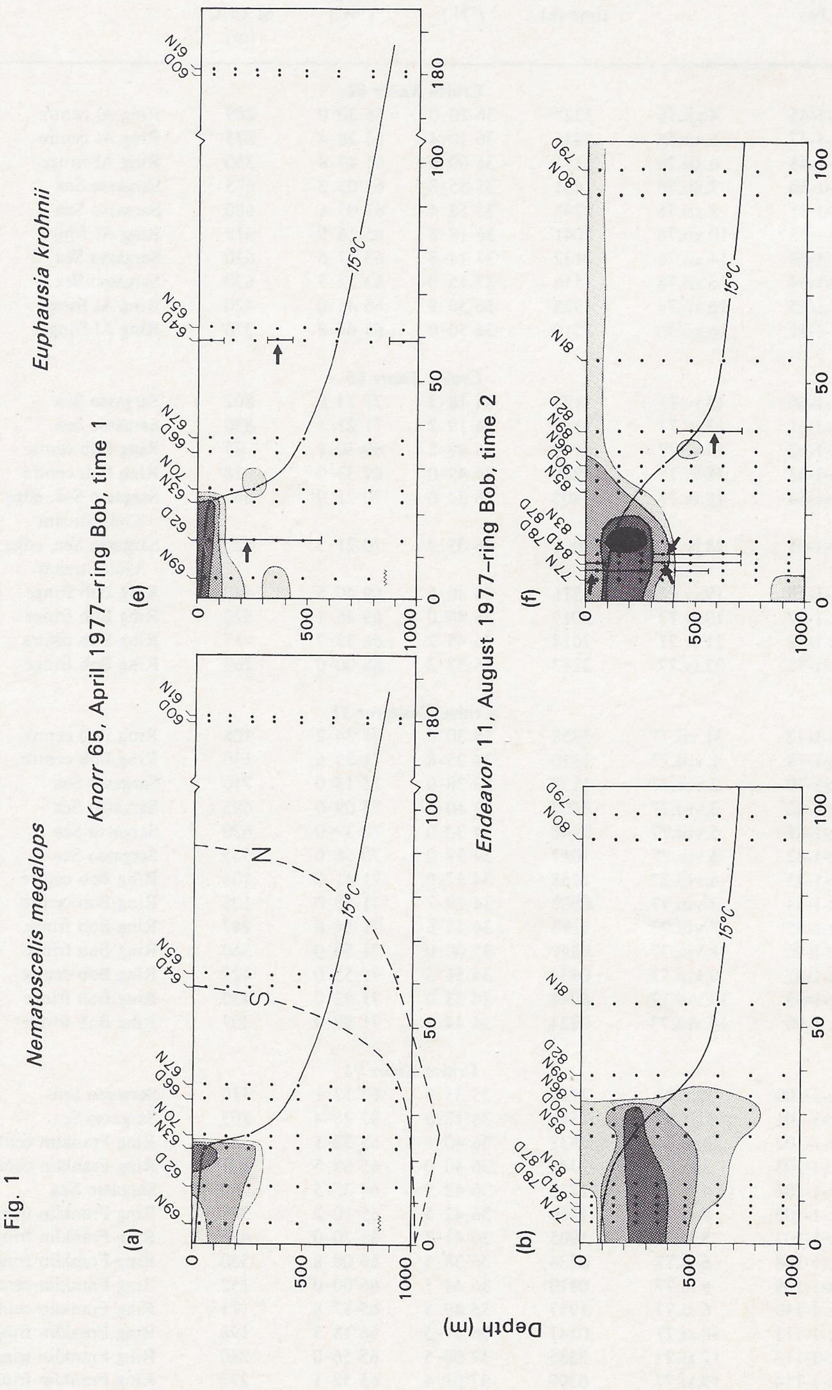

Nematoscelis megalops
Euphausia krohnii
Knorr 65, April 1977–ring Bob, time 1
Endeavor 11, August 1977–ring Bob, time 2
(a)
(b)
(e)
(f)
Depth (m)
15°C
N
S
0
500
1000
50
100
180

Fig. 1

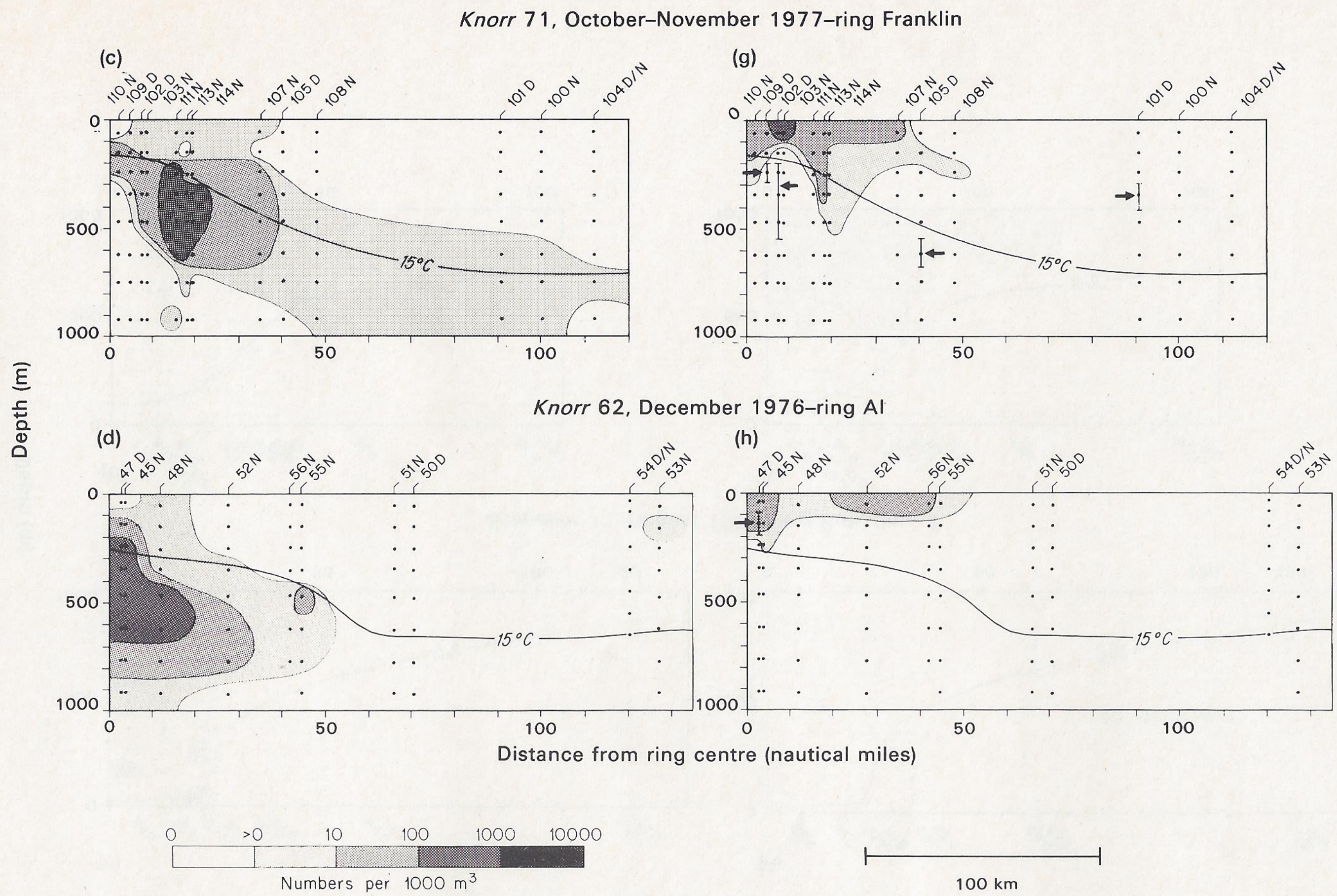


Fig. 1. Vertical sections of abundance of the Slope Water species *Nematoscelis megalops* and *Euphausia krohnii* in the cold-core ring/Sargasso Sea. Four cruises are illustrated for each species, two to ring Bob, *Knorr* 65 and *Endeavor* 11, one to ring Franklin, *Knorr* 71, and one to ring Al, *Knorr* 62. The solid line is the depth of the 15°C isotherm. For species that show strong diel vertical migration, night data are contoured and day data are given as the range (vertical bar) with an arrow indicating the centre of the distribution. The number/letter combinations along the top of each section are the MOCNESS tow numbers (D, day tow; N, night tow). The dashed lines in the top left section (*N. megalops*, *Knorr* 65) are the approximate north (N.) and south (S.) positions of the trapped region of a ring moving westward at 5 cm s^{-1}.

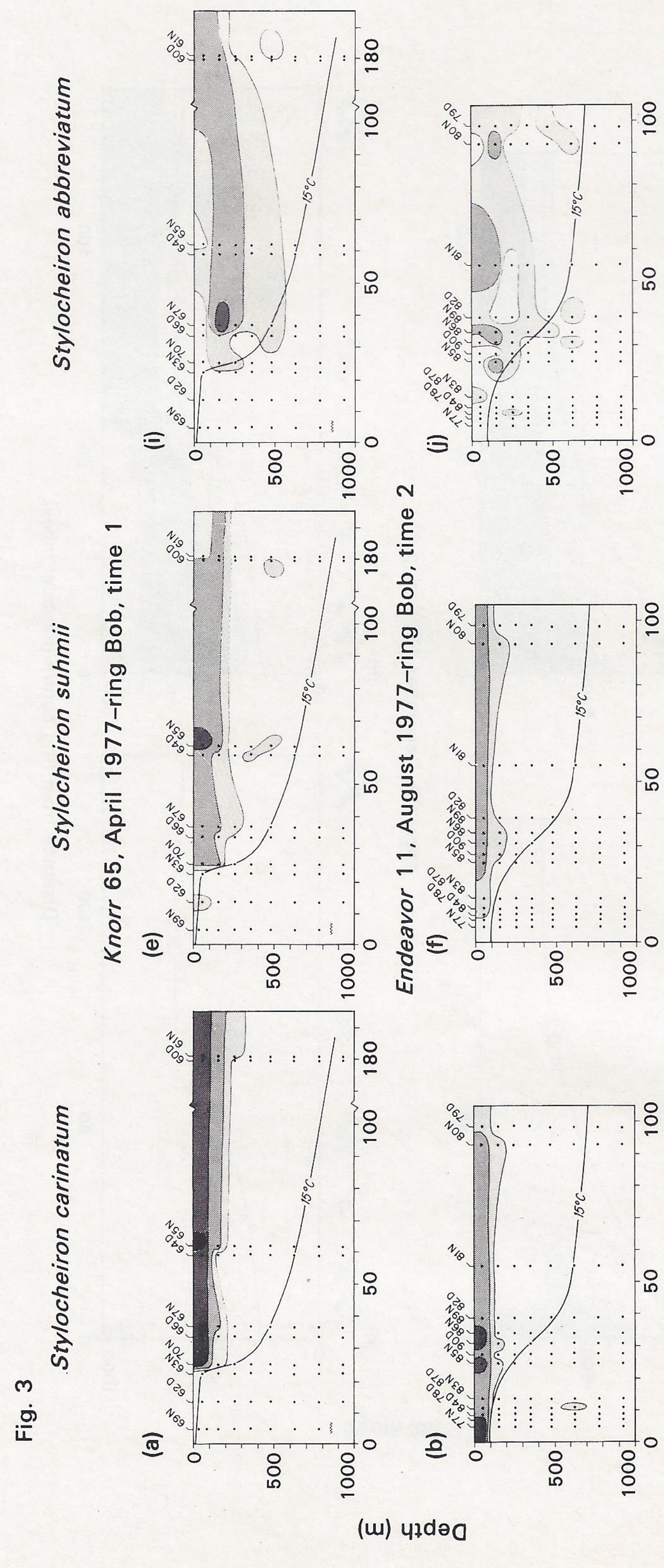

Stylocheiron carinatum
Stylocheiron suhmii
Stylocheiron abbreviatum
Knorr 65, April 1977–ring Bob, time 1
Endeavor 11, August 1977–ring Bob, time 2
(a)
(b)
(e)
(f)
(i)
(j)
Depth (m)
0
500
1000
50
100
180
15°C

Fig. 3

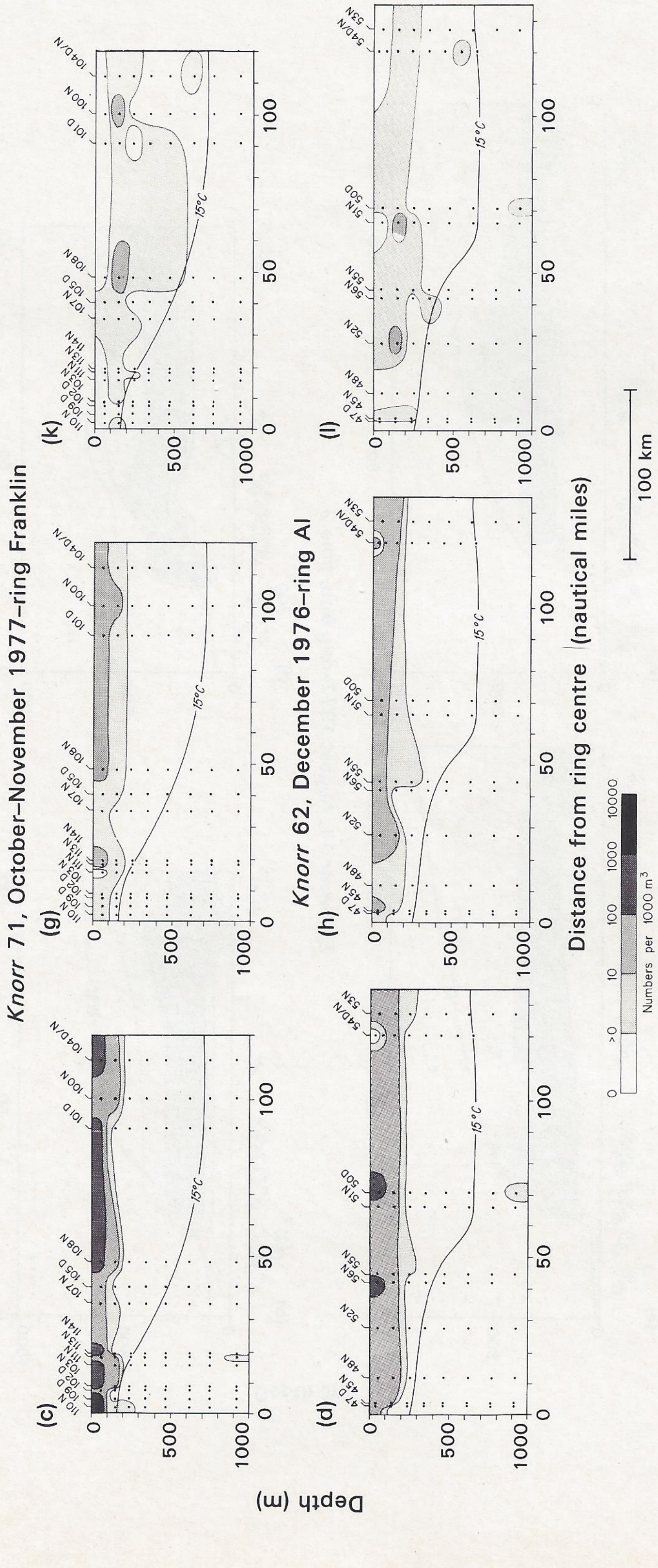


Fig. 3. Same as Fig. 1, but for the Sargasso Sea species *Stylocheiron carinatum*, *S. suhmii* and *S. abbreviatum*.

Ring Al does show greater penetration by warm-water species than the previously described rings. *Thysanopoda aequalis* (Fig. 5*l*), the species of *Euphausia* (Figs 6*d*, 6*h*, 6*l*), and the shallow-dwelling *Stylocheiron* species (*S. carinatum* and *S. suhmii*; Figs 3*d*, 3*h*) all had abundances in this ring equal to or greater than those in the adjacent Sargasso Sea. However, the deeper-living *Stylocheiron* (Figs 3*l*, 4*d*, 4*h*) and *Nematoscelis* species still had not reached the abundance levels found outside the ring. Furthermore, cold-water species such as *N. megalops* (Fig. 1*d*), *Thysanoessa longicaudata* (Fig. 2*d*) and *E. krohnii* (Fig. 1*h*) were still quite abundant within the ring and occurred only in low numbers or were absent beyond the ring core.

Fig. 7

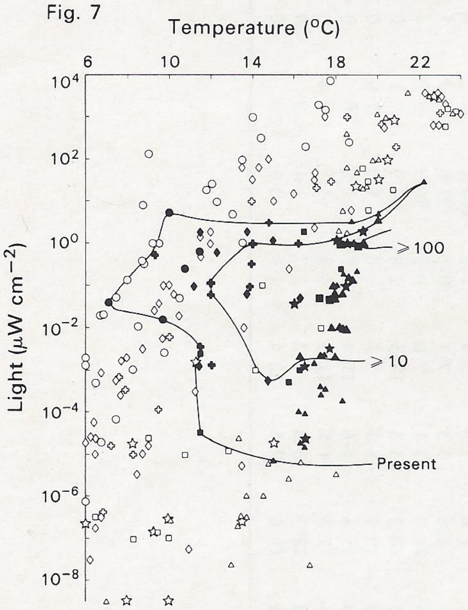
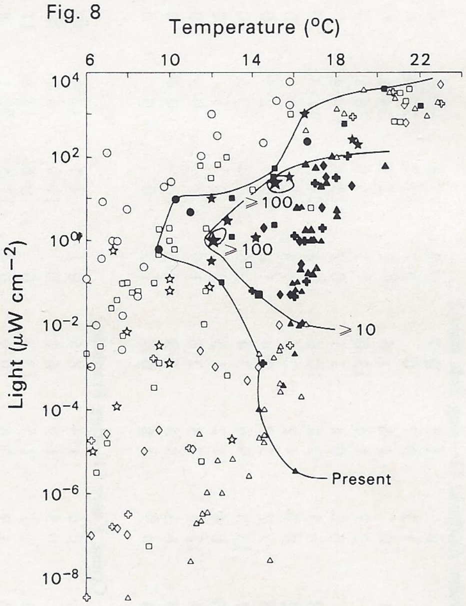


Fig. 8



Figs 7 and 8. Abundance of *Stylocheiron elongatum* (*7*) and *Stylocheiron affine* (*8*) versus temperature and light for all MOCNESS tows taken during daytime in the North-western Atlantic. Open symbols represent samples taken in which no individuals of this species were present; solid symbols represent positive occurrences. Small symbols represent fewer than 10 individuals; medium-sized symbols represent 10 to 99 individuals; large symbols represent 100 or greater individuals. Symbols are plotted at the midpoint of temperature and light for the depth strata sampled. Lines divide the observations into particular classes; for example, the line labelled ≥10 encloses all observations in which 10 or more individuals were found. Note that some of the samples within this area may contain fewer or no individuals. ● Slope Water. ▲ Sargasso Sea. ★ Warm-core ring. ■ Centre of cold-core ring. ◆ Fringe of cold-core ring. + Gulf Stream.

Ring Influence on Vertical Distribution and Diel Migration

The warm-water euphausiids that penetrate cold-core rings exhibit a common reaction of shoaling in their depth distribution. In the vicinity of a ring, the shoaling often involved truncation of the lower portion of the depth distribution by 100–300 m and for deep-dwelling species, elevation of the upper limit by about 100 m. The pattern is most pronounced in young rings such as Bob and less evident in the older rings Al and Franklin. For non-migrators living near the surface (*S. carinatum*, *S. suhmii*), the shoaling is subtle (Fig. 3). These species typically range the upper 200 m in the Sargasso Sea, but become restricted to the upper 100 m in young rings. For deeper-living non-migrators (*S. affine*, *S. elongatum*), shoaling is more dramatic (Fig. 4). The day and night vertical distributions does not show a fairly sharp change in the compositional structure when moving out from the centre of the ring, although there is a definite break beyond a 15°C isotherm depth of 400 m. This is due primarily to individuals of species such as *S. carinatum* and *Thysanoessa parva* being abundant across the entire area and thus damping the contrast.

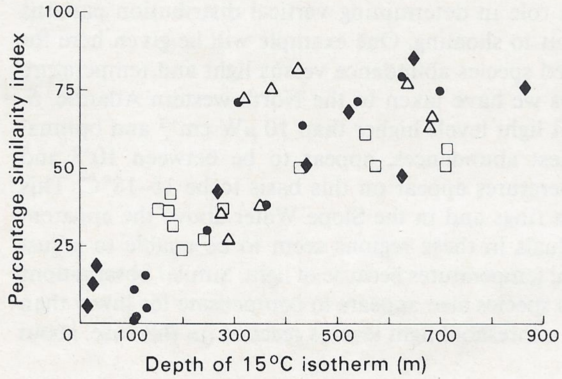


Fig. 9. Percentage similarity of the 15 euphausiid species used in this study, based on a comparison of each station in a section with the outermost station going from the ring centre to Sargasso Sea, versus the depth of the 15°C isotherm. □ Ring Franklin. △ Ring Al. ◆ Ring Bob, time 1. ● Ring Bob, time 2.

Discussion

Summary of Observations

The pattern that emerges is the following:

(1) Warm-water species living permanently at or near the surface and those that perform diel migrations invade a ring more quickly than do species that live at subsurface depths of 150–600 m. However, even for these rapid invaders, there is often a tendency for population numbers to be lower within the ring compared to adjacent seas for 6 months or more.

(2) Vertical migrators migrate to shallower depths in young rings and non-migrators show a strong tendency to shoal.

(3) Cold-water species persist within the ring core for extended periods. In some cases, species can enlarge their population numbers in middle-aged rings over levels present at the time of formation; i.e., *E. krohnii* and *N. megalops*. Other species such as *Thysanoessa longicaudata* can show rather drastic declines in numbers during this same period in rings like Bob.

(4) Cold-water species, such as *N. megalops* and *T. longicaudata*, which show submergence as a ring ages, appear to be dispersed out of a ring at depths of 400–1000 m. For the shallower-dwelling species like *E. krohnii*, which can survive surface-water modification, dispersal appears to take place near the surface.

(5) The species compositional structure of the core of these rings remains distinctly different from the surrounding Sargasso Sea for 6–8 months after formation in spite of the exchanges of species into and out of the ring that appear to be taking place. These data corroborate the earlier findings of Wiebe *et al.* (1976*a*).

Mechanisms of Population Change

We cannot offer any complete explanation of how the population changes we have described arise, but we can attempt to list the various mechanisms and make estimates of the likely contribution of each process to the alteration of the distributions. These mechanisms fall into three classes: