## Euphausiids in the Korean waters and its relationship with major fish resources

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Euphausiids are very important food resources for major fish resources, squid, mackerel, whales and so on in Korean waters. Euphausiids have shown an increasing recently trend in composition of major zooplankton groups, and 10 species were identified from the Korean waters. Until recently, little work has been done in longterm change in abundance of euphausiids in related to climate change and the importance of fish resources in the Korean waters. This study is focus on general distributional pattern, the regional patterns of long-term changes in abundance and the relationship between euphausiid and fish abundance in Korean waters.



**Fig. 1** Map showing the study area and stations; date indicate oceanographic survey stations.

The National Fisheries Research and Development Institute has conducted regular oceanographic surveys 6 times annually (February, April, June, August, October and December) since 1965 in the Korean waters (Fig. 1). From this survey, euphausiids were collected by NORPAC net (0.45 m mouth and 0.33 mm mesh size) with vertical tow from bottom (or 100 m depth) to surface. For this study, data on euphausiid abundance and surface water temperature during 1978-1998 were used. Catches of squid, mackerel and anchovy were analyzed during 1978-1998 in comparison with abundance of euphausiid.

The following 10 species were identified from the Korean waters: Euphausia recurva, E. mutica, E. pacifica, E. nana, E. tenera, E. similis, Pseudeuphausia latifrons, Stylocheiron affine, S. carinatum, and Thysanoessa longipes. Of these species, E. pacifica, E. nana and P. latifrons were numerically dominant. Seven other species were associated with the influx of the Tsushima Warm Current. E. pacifica had a discontinuous distributional pattern. It was found in the Sea of Japan and the northern part of the Korea Strait, and the Yellow Sea. E. nana occurred in the intervening area, with some overlap with E. pacifica in the east and west.

From distribution of mean abundance of euphausiids during 1978-1998 in the Korean waters it is recognized that euphausiids were densely populated in the coastal area and the western area of Cheju Island in April and June. Although their abundance was very low, they usually aggregated in the coastal area in February, August and October.

Comparing among three separated subareas, east, west and south areas, the south area showed the highest abundance, while the east area was low.

There was a conspicuous seasonal change with the regional variation. In Korean waters a large peak appeared in spring, April and June, and a small peak occurred in autumn, October. In the south area this pattern is very clear, while in the west and east areas it was not clear.



**Fig. 2** Year-to-year changes in euphausiids abundance in the Korean waters during 1978-1998.

The annual average abundance from 1978-1998 was 2.52 ind.•m<sup>-3</sup>. The euphausiids showed an increasing trend since the early 1990s with two increasing periods (Fig. 2). The first occurred from the late 1970s to the early 1980s and the second occurred after 1990. The increase after

1990 was closely associated with the increase of surface water temperature in winter, February and December.

Year-to-year changes in catches of major fish resources, Engraulis japonica, Scomber japonicus and Todarodes pacificus were compared to euphausiid abundance. Engraulis japonica and Scomber japonicus are major fish resources in the South Sea, while Todarodes pacificus is in the East Sea of Korea. Engraulis japonica and Scomber japonicus began to increase since 1992 with extraordinary increase in 1993 and 1996, respectively. It did not coincide with euphausiid abundance, but there was a possibility that the increasing trend after 1990 in euphausiids abundance accompanied with increases of Engraulis japonica and Scomber japonicus after 1992.

*Todarodes pacificus* increased continuously after 1990. It was closely related to the increase of euphausiid abundance in the East Sea of Korea.

## **Ecological Zonation of euphausiids off central Oregon**

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## Introduction

The euphausiids Euphausia pacifica and Thysanoessa spinifera dominate the euphausiid assemblage along the west coast of North America from Baja California to the Gulf of Research in the northeast Pacific has Alaska. shown that the two species share a common latitudinal range but that T. spinifera is a coastal species, restricted to shelf waters while E. pacifica is an oceanic species. For example, off southwestern Vancouver Island, Mackas (1992) showed that T. spinifera is the dominant euphausiid species in shelf waters and is the only euphausiid common in water depths shallower than about 150 m whereas E. pacifica is dominant along and seaward of the shelf break. Off Newport, OR, Smiles and Pearcy (1971) found that Euphausia pacifica was far more abundant near the shelf-break than offshore, peaking at a station 25 miles from shore (250 m water depth). In the same data set, T. spinifera was found chiefly at a station 15 miles from shore (90 m water depth) but not farther offshore (Smiles, unpublished data). Peterson and Miller (1976), who worked off Newport in 1971 and 1972, did not find E. pacifica closer to shore than 20 miles (150 m depth), nor T. spinifera further from shore than 20 miles. Thus, off central Oregon the two species have their maxima in abundance at stations within a few miles of each other, with