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Fluctuations in abundance of common squid, *Todarodes pacificus* in the far east

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Abstract: *Long term fluctuations in the abundance of common squid, Todarodes pacificus are taken in the waters around Korea and Japan from 1952 to 2003. The year-to-year fluctuations in the abundance in the Tsushima Warm current (TWC) region (Yellow sea- east China sea-east/Japan sea) revealed the same pattern with that in the Kuroshio-Oyashio Current (KOC) region (Northern Pacific) except for the period of fishing shifts from the KOC to TWC region in the late 1960s and 1970s. Two period of high abundance in the entire fishing regions emerged in the 1950s-1960s and 1990s, in-between there has been a low level in the KOC region for 20-years (1970s-1980s) and in the TWC region for 10-years (1980s). The squid fishery in the marginal zone of the distribution range (KOC region) was mainly based on winter –breed microcohort that collapsed earlier (from the early 1970s) than that of the fishery in the central zone (TWC region), based on autumn and winter-breed microcohorts from the mid 1970s. During the low abundance period (1980s) the catch rates of the autumn microcohort were higher than those of the winter microcohort, while the abundance of the two increased schynchronously from the early 1990, suggesting the possible homogeneity of the population structure during the high abundance period.*

Key words*: Common squid, Population structure, Abundance, Tsushima warm current, Kuroshio-Oyashio current region*
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Introduction

Common squid, *Todarodes pacificus* is a nerito–oceanic species ranging in its distribution from the Philippine sea to the central Okhotsk Sea, being most abundant in the waters around Korea and northern Japan. The squid in the Tsushima warm current (TWC) region (Yellow sea-East China sea-East/Japan sea) have been exploited mainly by Korea and Japan and the squid in the Kuroshio-Oyashio current (KOC) region (Pacific off northern Japan and Okhotsk sea) mainly by Japan (Fig. 1). Three seasonal spawning groups (microcohorts) are known in the common squid population, of which winter-group has the widest distribution around Japan and the autumn group has its highest density in the East/Japan sea (Murata, 1991; Sakurai *et al*., 2000).

However, it is suggested that the population structure must be reexamined because of the extensive overlap in the migration routes of the spawning groups (Nakata, 1990; Mori and Nakamura, 2001; Kiyofuji and Saitoh, 2004; Kawabata *et al*., 2006), and that the population structure varied during different periods of abundance level (Nakata, 1993; Kubota and Kawabata, 1996).

The present paper examines the long-term changes in abundance of the population by region and by spawning group to explain any changes in population structure in association with the changes in the abundance.

Materials and Methods

Year-to-year catches of *T. pacificus* in the waters around Korea and Japan are based on the annual Yearbooks of Fishery Statistics from 1952 to 2004, and on the various papers and reports (Suzuki, 1963; Gong and Oh, 1977; Shingu *et al*., 1983; Ogawa and Sasaki, 1988; Nakata, 1993; Kubota and Kawabata, 1996 and Sakurai *et al*., 2000). Year-to-year catches by winter-spawned and autumn- spawned groups are based on the data from Korea and Japan (Hokkaido National Fisheries Research Institute, 2006; Japan Sea National Fisheries Research Institute, 2006). Year-to-year catch per unit fishing effort (CPUE) for squid fishing by Korea (Choi *et al*., 1997; Gong *et al*., 2007) is used to examine the fluctuations in abundance.

Results and Discussion

Year-to-year catches of the squid by Japan in the Pacific (KOC region) were about two times higher than those by Korea and Japan in the TWC region in the 1950s and 1960s with positive relationship, while catches in the TWC region were about three times higher than those in the KOC region in the 1970s, 1980s and 1990s with positive relationship ($r = 0.551$, $p < 0.01$) (Fig. 2). Annual average catch per unit effort (CPUE) and density indices from jigging fishing by Korea and Japan in the TWC region (mainly in the East/Japan sea) were low in the 1980s but increased in the 1990s (Fig. 3), which shows the same trends as the year-to-year catch fluctuations.

If the catch and CPUEs for the squid are regarded as indices of fluctuations of the population abundance, it follows that the year-to-year and long-term changes in abundance of the population in the TWC and KOC regions have the same pattern with synchronous increase and decrease since the mid–1970s. Catches for autumn-spawned group were two times higher than those for winter-breed group during the low population abundance in the 1980s, while the catches for both groups were equally high in the

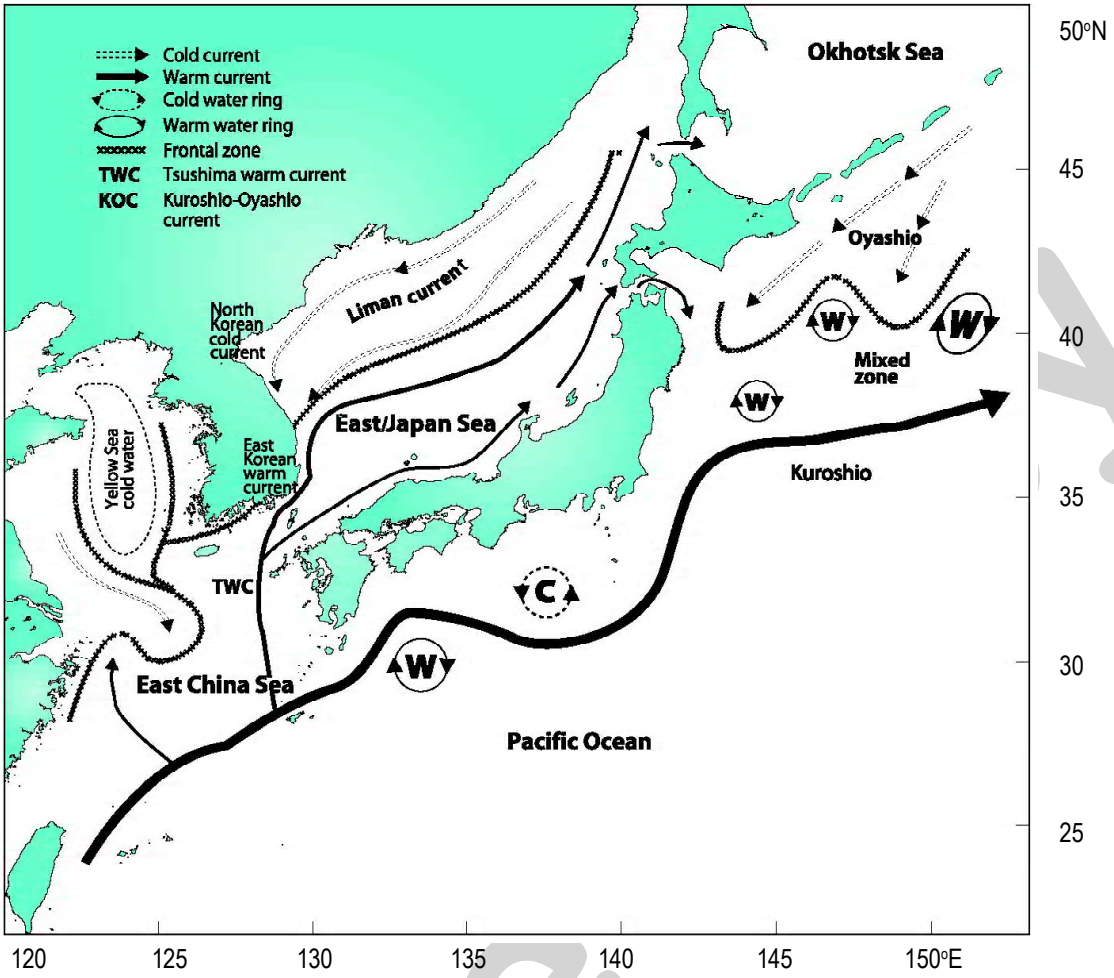

Fig. 1: Schematic current systems in the East/Japan sea and its adjacent waters. TWC region indicates the East/Japan sea, East China sea and Yellow sea. KOC region indicates the Kuroshio-Oyashio current regions and the Okhotsk sea

TWC and KOC regions during the high population abundance in the 1990s (Fig. 4).

Common squid, *Todarodes pacificus* were caught in the coastal and offshore zones of the TWC and KOC regions mostly by jigging boats before 1980s. However, about three quater of the annual catches are taken by jigging and trawlling with cooperated jigging from the mid-1990s. The catch in the KOC region began to decline from the early 1970s after the big catch in 1968 and remained low during the 20 years period 1971~1990 (Ogawa and Sasaki, 1988; Kubota and Kawabata, 1996). However, the catch in the Tsugaru strait began to decline from the mid-1970s and remained low during the period 1976-1989 as that in the East/Japan sea, and the catch increased in both areas in the early 1990s (Kubota and Kawabata, 1996; Sakurai *et al*., 2000).

As soon as the fishery in the north Pacific (KOC region), based on the winter spawned group had collapsed (Okutani and Watanabe, 1983) in the early 1970s, Japanese jigging fleets moved to the offshore and northern East/Japan sea (main fishing ground of the TWC region) where the squid population was at its peak in the 1960s and the early 1970s (Kasahara, 1978) (Fig. 2). A large amount of the squid taken by the fleets in the later fishing grounds (TWC region) were landed at the fishing ports along the pacific coast (main KOC region) during the period of the late 1960s and 1970s (Kasahara, 1978, 1983 ; Kawai, 1995), which are recorded as high as those in the TWC region in the official Yearbooks of Fishery Statisties of Japan. Therefore, the actual catches of the squid from the KOC region were extremely low during the period of 1970~1990 (Fig.2). Common squid in the Yellow sea have been exploited by Japan since 1974 and much of them were landed at the fishing ports along the western Japan (Kyushu) (Gong and Oh, 1977; Kasahara, 1977, 1978). The Squid catches by Korean fleets in the Yellow Sea amounted to about 40,000 tonnes in the mid-1980s (Choi *et al*., 2003)

The year-to-year catch and catch per unit effort (CPUE) revealed the same trend of fluctuations in the 1980s and 1990s when the later data were available (Fig. 2, 3). Even though the catches in the TWC region were smaller than those in the KOC

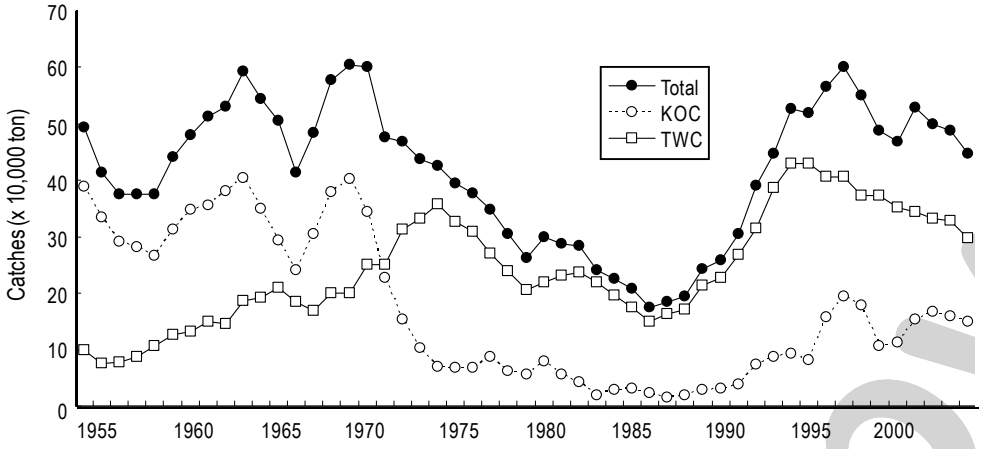

Fig. 2: Trends in the annual catches of *Todarodes pacificus* by Korea and Japan in the Tsushima warm current (TWC) region and by Japan in the Kuroshio-Oyashio current (KOC) region, and the Total, 1952~2004 (3-year running average)

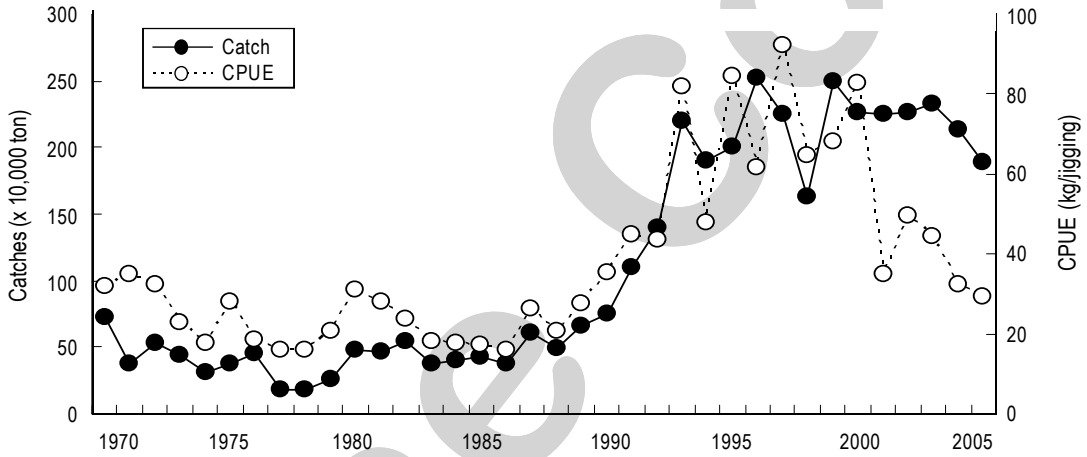

Fig. 3: Catch (dark circle) for Korean squid fishery and catch per unit effort (CPUE, open circle) for Korean jigging fishing, 1970-2005

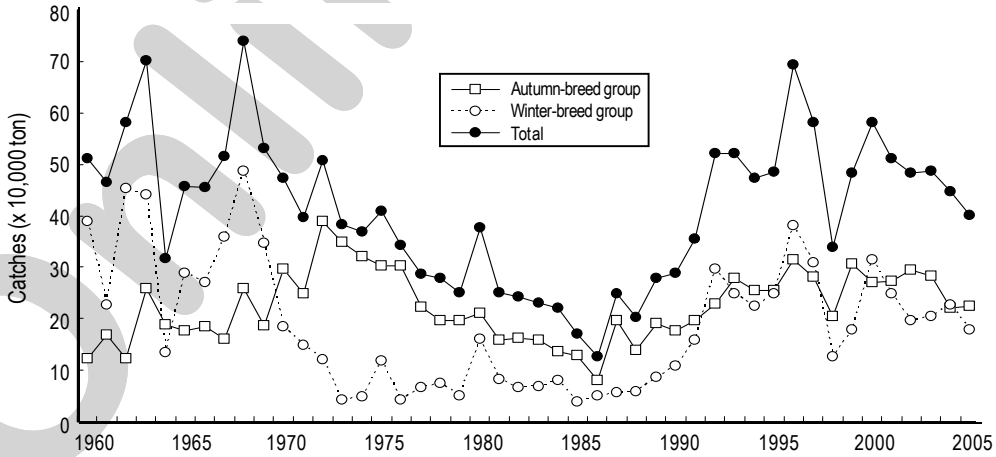

Fig. 4: Catches of autumn-breed group, winter-breed group and total of *Todarodes pacificus* taken by Korea and Japan in the Tsushima warm current region and by Japan in the Kuroshio-Oyashio current region, 1960-2005

region in the 1950s and 1960s, the abundance of the population seems not to be so low because the squid were not fully harvested due to the poor fishing techniques and low availability of the population, in particular, in the early stage of Korean fishing (Gong and Oh, 1977). The negative correlation between the catches in the two regions during the period of the late 1960s and early 1970s are attributed to the shifts of Japanese fleets from the KOC region to the TWC region due to the earlier collapse of the fishing in the former region. Therefore, it is postulated that the level of the abundance of the common squid in the entire distribution range was higher in the 1950s and 1960s than in the 1990s.

The abundance of common squid population in terms of year-to-year catch and catch per unit effort in the waters around Korea (TWC region) and the north Pacific off northern Japan (KOC region) from 1952 through 2003, the abundance in the first high level period (1950s and 1960s) seems to be higher than that in the second high period (1990s). The year-to-year fluctuations in the abundance showed the same pattern in the two regions except the period of shift of fishing from the KOC to the TWC region in the late 1960s and 1970s. In brief, the abundance of the squid population in the marginal zone (KOC region) decreased earlier than that in the central zone (TWC region) due to the shift of heavy fishing.

In the year-to-year fluctuations in catch rates by microcohorts (autumn-breed and winter-breed) of the squid population, the level of both cohorts were high during the high abundance period in the 1990s, which suggest the possible homogeneity of the population structure in the entire distribution range. Further discussion is needed for the possible mechanism on the homogeneity of the population structure.

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