Interannual Variability in Neon Flying Squid Abundance and Oceanographic Conditions in the Central North Pacific, 1982-1992

Akihiko YATSU* and Tomowo WATANABE*

Abstract

Neon flying squid, *Ommastrephes bartrami*, was the target species of the Japanese squid driftnet fishery in the Central North Pacific during 1978-1992. Interannual variation in neon flying squid catch-per-unit-effort (CPUE) in this fishery during 1982-92 was highly correlated ($r=0.79$, $P<0.01$) with that of the Hokkaido University's research driftnet surveys along 175° 30'E in July which coincided with the peak of the commercial fishery. This CPUE variability was strongly affected by water temperature and salinity structures around the Subarctic Boundary. Importance of monitoring neon flying squid abundance were also discussed.

Introduction

Neon flying squid, *Ommastrephes bartrami*, is one of the dominant nekton in the epipelagic subtropical and subpolar waters of the world oceans and undertakes extensive seasonal north-south migrations (Seki, 1993). This species was the target of the squid driftnet fisheries of Japan, Korea and Taiwan in the Central North Pacific during 1978-1992. The total annual catch by these three countries fluctuated between about 200,000 and 300,000 metric tons (Yatsu *et al*., 1993, 1994). The annual catch-per-unit-effort (CPUE, catch in kg per tan or a net panel) also varied between 4.2 and 8.6 during 1982-92 in the Japanese fishery operating between longitudes 170°E and 145°W and latitudes 35°N and 46°N (Yatsu *et al*., 1994) ; and between 3.4 and 6.7 during 1983-90 in the Korean fishery operating between longitudes 141°E and 151°W and latitudes 30°N and 46°N (Gong *et al*., 1993a). The patterns of interannual variations in CPUE were almost identical between these fisheries since 1984 (Gong *et al*., 1993a).

The closure of the large-scale high seas driftnet fisheries was in effect by the end of 1992 according to the United Nations Resolutions 44/225 and 46/215 (Burke *et al*., 1994). Responding to the demand of neon flying squid in the Japanese market, the Fisheries Agency of Japan has been trying to develop alternative fishing technologies in place of the driftnet since 1992. In recent years, a jig fishery for neon flying squid is expanding toward offshore of the North Pacific.

Importance of this species has been recognized not only as a fishery resource, but also as a

1996年3月6日受理　遠洋水産研究所業績　第330号

* 遠洋水産研究所 (National Research Institute of Far Seas Fisheries ; 7-1, Orido 5-chome, Shimizu-shi, Shizuoka 424, Japan)

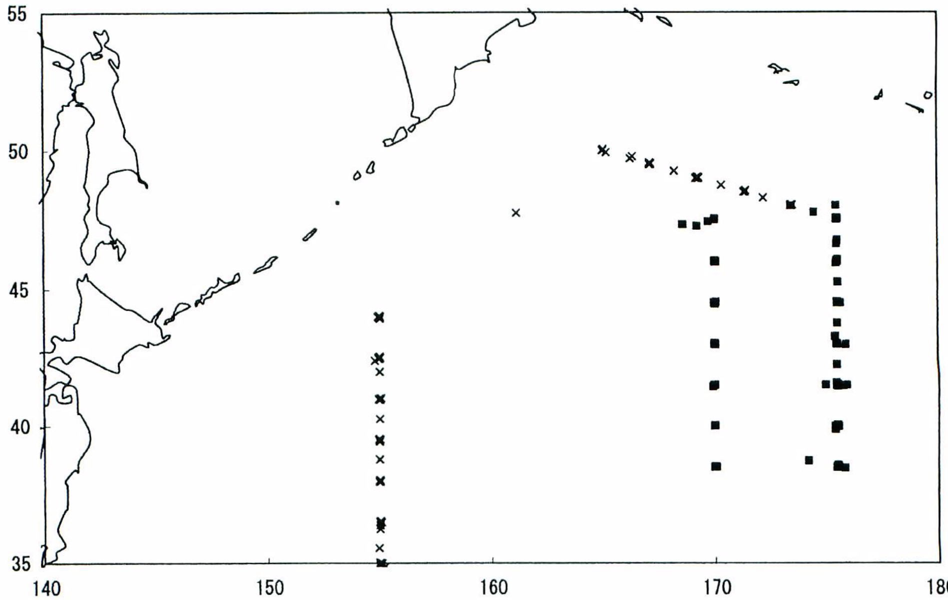


Fig. 1. Location of driftnet stations by Hokusei Maru, 1979-93.
■ : stations used for present paper, repeated mostly in late July every year;
x : stations excluded from analysis.

member of the North Pacific pelagic ecosystems (Seki, 1993). Since the interannual variability in abundance for neon flying squid probably affects productivity of the ecosystems, it is necessary to monitor the abundance in order to evaluate its effects.

Since 1978, the Hokkaido University has been conducting oceanographic and driftnet surveys using its training vessel, Hokusei Maru, in the North Pacific Ocean at the almost fixed sites and period every year (mostly along longitudes 155°E, 170°E and 175° 30'E between latitudes 35°N and 50° N during June-August). This data set were used for studying interrelationship between oceanographic conditions and distribution of pelagic nekton communities (Ignell *et al.*, 1995) and Pacific pomfret (*Brama japonica*), one of the most dominant nekton in the North Pacific (Pearcy *et al.*, 1993). The purposes of this paper are: (1) to examine the possibility of Hokusei Maru's data set as an indicator of the neon flying squid abundance, and (2) to discuss possible causes of interannual variability of CPUE in the commercial fishery.

Material and Methods

The catch and effort statistics in the Japanese squid driftnet fishery (JSDF) were taken from a series of reports by Fisheries Agency of Japan (1984-93) and Yatsu *et al.* (1994). The statistics were not available for the initial stage of the fishery (1978-81). Distribution of CPUE of neon flying squid was compared with surface temperature distribution based on the Comprehensive Ocean

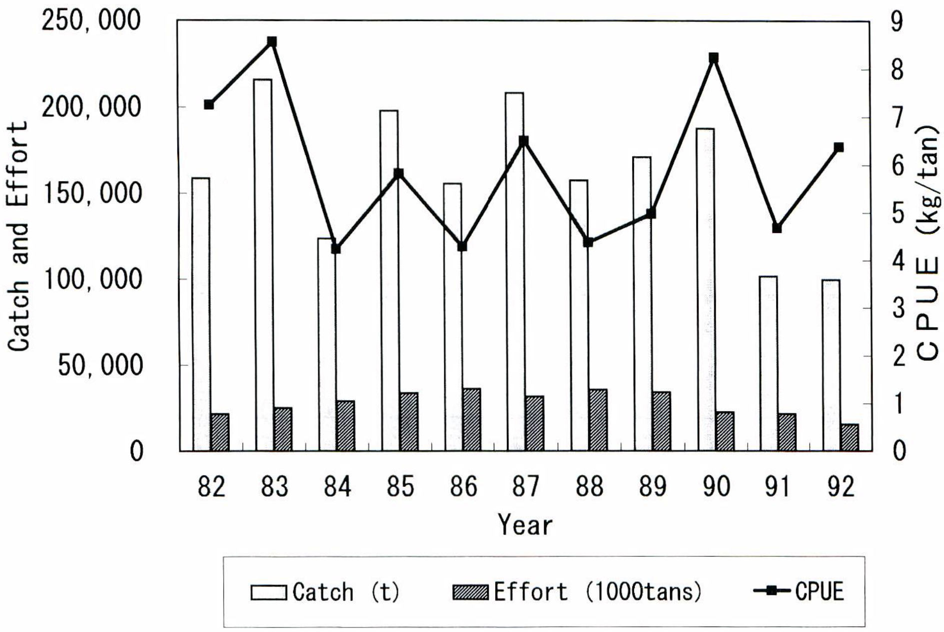


Fig. 2. Neon flying squid catch, effort and CPUE statistics for the Japanese squid driftnet fishery during 1982-92. Statistics of the initial stage of the fishery (1978-81) are not available.

Atmosphere Data Set (COADS) which was supplied from the Japan Meteorological Agency as the monthly means in two-degree latitude and longitude blocks.

The stretched mesh size of JSDF ranged from 100 to 135 mm and the tan (net panel) length varied between 30 m and 60 m during 1982-88 and standardized at 50 m after 1988. Fishing grounds were usually confined within 180 nautical miles south of the regulated northern boundary (42°N in July ; Yatsu *et al.*, 1993, 1994), which were established to avoid incidental catch of salmonid fishes. Dorsal mantle lengths (ML) of the neon flying squid were measured on selected commercial vessels by scientific observers in 1991.

The Hokusei Maru's data on driftnet operations and oceanographic observations for 1978-1993 were obtained from a series of reports by Hokkaido University (1979-1994), except for the corresponding catch data of neon flying squid in 1978. At each site, one driftnet fishing set and a CTD cast were conducted. The total number of tans of driftnets used per site was 49 (1993) or 90-133 (1979-92). This included 11-63 tans (550-3,150m in total length) of commercial meshed nets (112-121mm) and 38-50 tans (2,500m) of non-size-selective nets (composed of 19 mesh sizes ranging from 19mm to 204mm ; see Takagi, 1975). In this study, we used data from 183 sites located at longitudes 170°00'E and 175°30'E (corresponding to the western part of the JSDF fishing grounds), and latitudes between 35°N and 48°N surveyed mostly in late July (Fig. 1). In total, 20,825 neon flying squid were collected and ML of 12,520 individuals were recorded.

Neon flying squid stocks consist of a number of putative cohorts which are distinguished by the

Table. 1 Monthly catch per unit effort (CPUE, kg/tan) of neon flying squid by the Japanese squid driftnet fishery during 1982-92.

Month\Year	82	83	84	85	86	87	88	89	90	91	92
June	8.2	9.8	5.6	7.4	6.3	8.2	8.4	4.5	4.6	2.2	4.0
July	9.8	13.0	6.8	8.9	5.9	11.6	5.7	5.5	10.1	5.2	7.8
August	8.1	11.2	4.4	7.0	5.1	8.3	4.3	3.5	12.0	6.4	7.3
September	8.8	9.7	3.5	6.0	3.6	5.7	3.1	3.7	6.2	3.8	4.7
October	7.9	6.2	3.9	5.3	4.0	4.1	4.3	7.5	6.4	4.2	5.0
November	7.2	7.1	4.9	6.0	3.8	5.8	4.3	7.6	4.7	3.8	2.7
December	5.6	10.1	4.5	5.4	5.2	5.2	4.5	5.9	3.8	4.5	4.0
June-December	8.2	9.9	4.9	6.8	5.0	7.8	5.0	5.0	8.3	4.7	6.4

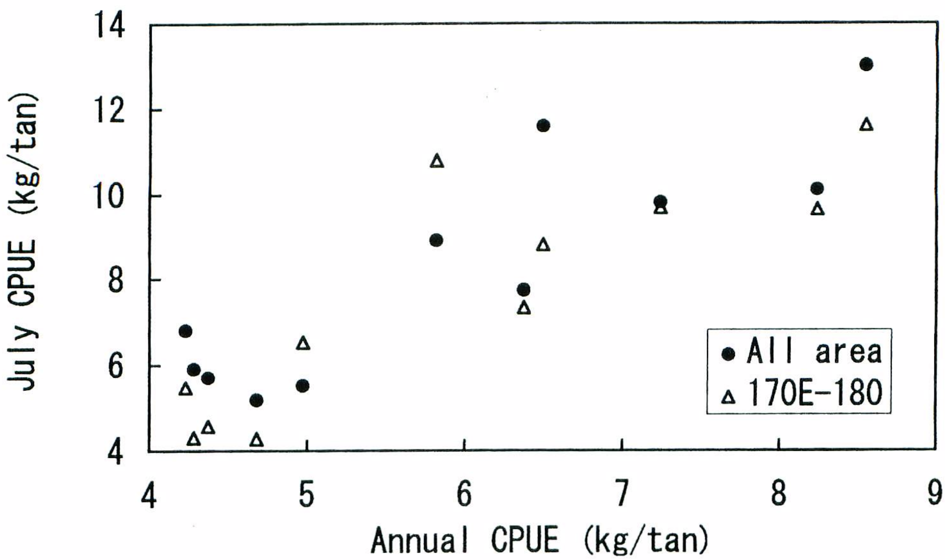


Fig. 3. Relation between July CPUE (●, entire fishing grounds (170°E-150°W); △, western area (170°E-180°)) and annual CPUE (170°E-150°W) of neon flying squid in the Japanese squid driftnet fishery during 1982-92.

mantle length composition (Murata, 1990) : extra-large (LL, mode of mantle length larger than 34cm during June-September), large (L), small (S) and extra-small (SS). LL group was targeted by JSDF during June-August, the peak season of this fishery (Murata and Hayase, 1993 ; Yatsu *et al*., 1993). During the Hokusei Maru surveys approximately 60% of the squid catch were measured for ML. In order to describe CPUE of LL group in each catch, it was necessary to estimate effective fishing effort and the catch in number of LL group ; the latter number was estimated using the proportion in the sample from corresponding fishing operation. Kubodera and Yoshida (1981) reported that (1) 106mm and larger mesh-sizes were effective in catching only the LL group and not smaller squid, (2) 93mm mesh nets could collect both the LL and other groups with relative efficiency of approximately 1 :2, and (3) 82mm and smaller meshes are ineffective for the LL group. Therefore, we used

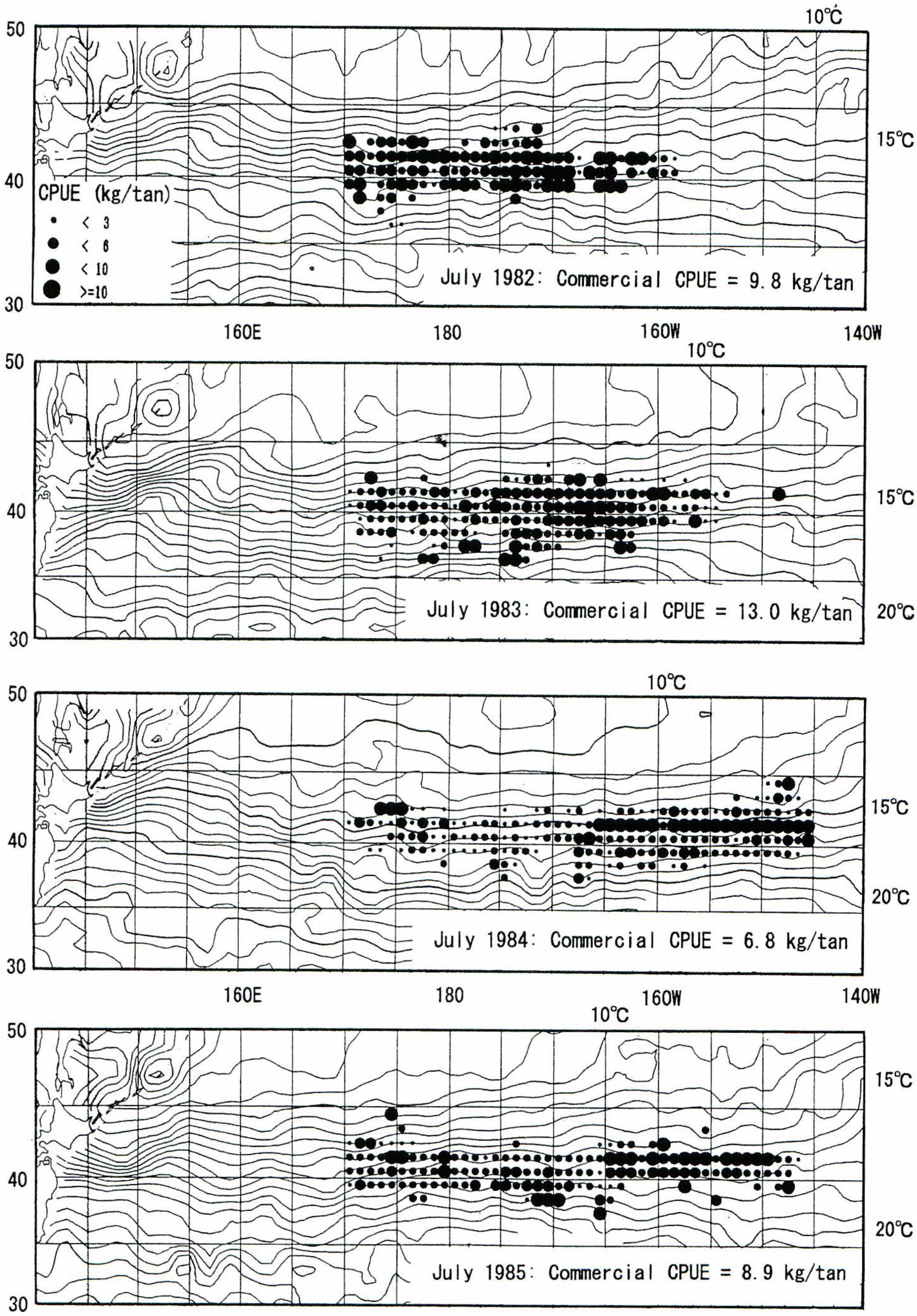


Fig. 4-1. Distribution of neon flying squid CPUE in the Japanese squid driftnet fishery and sea surface temperature in July 1982-85.

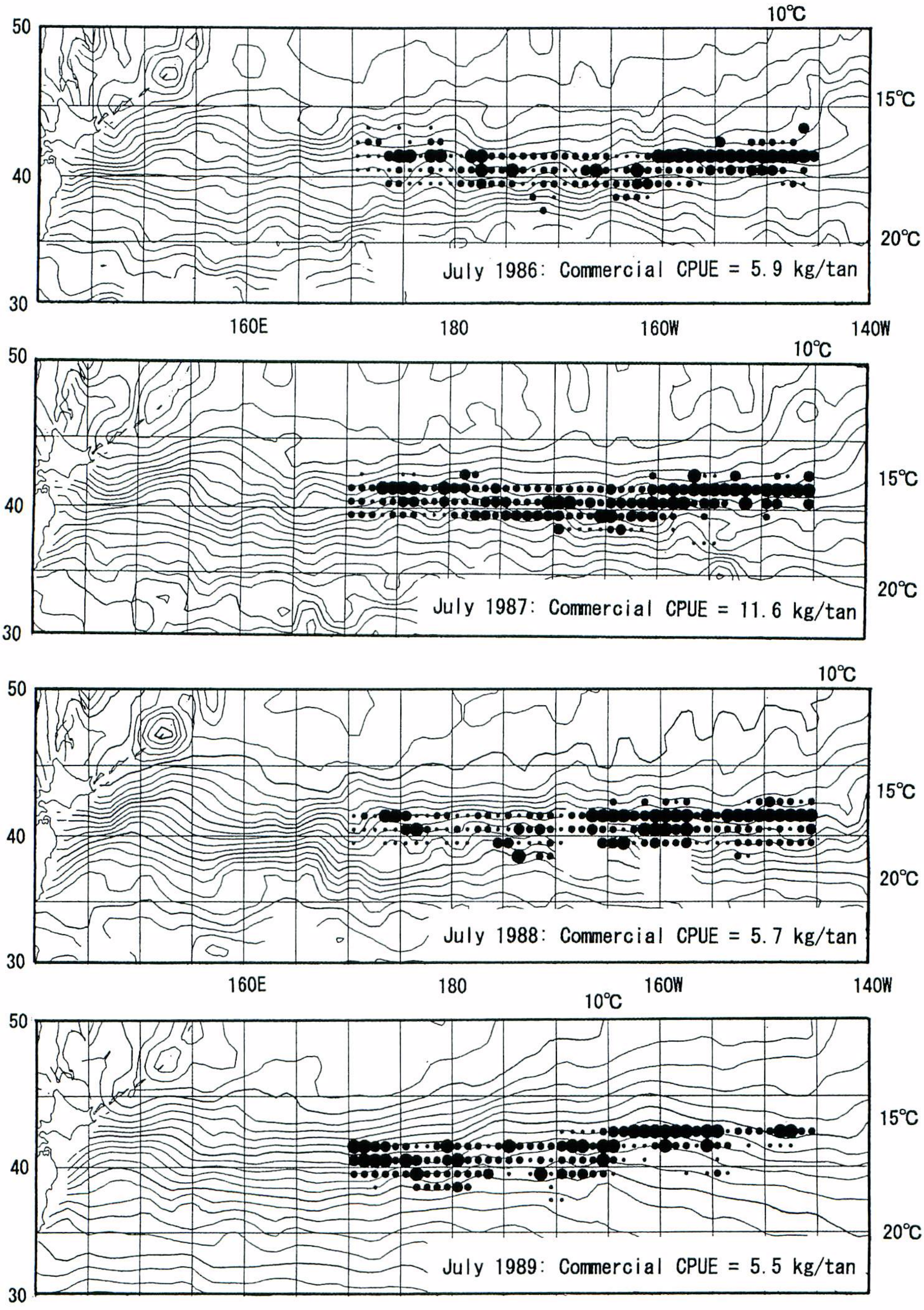


Fig. 4-2. Continued, 1986-89.

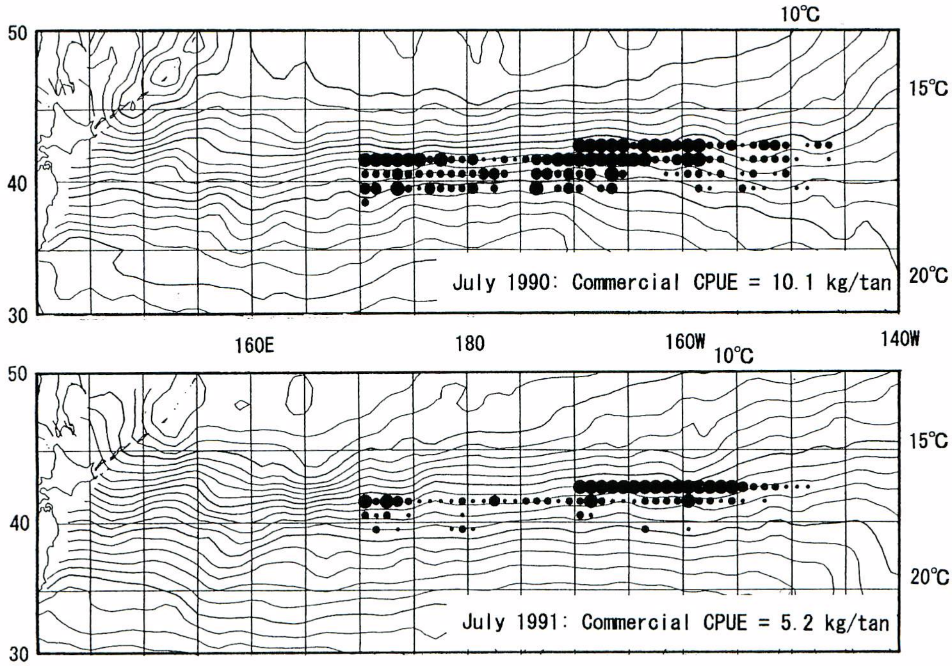


Fig. 4-3. Continued, 1990-91.

CPUE of the LL group by dividing total estimated catch in number by total number of tans (nets) whose mesh-size were 106mm and larger plus one third of 93mm mesh net.

Details of the data used are described in Yatsu *et al.* (1993, 1994), Hokkaido University (1980-94) and Pearcy *et al.* (1993).

Results and Discussion

1. Interannual variation in commercial CPUE

Total annual catch, fishing effort and CPUE of the JSDF are shown in Fig. 2. While fishing effort gradually increased from 1982 to 1986 and decreased from 1989 to 1992, both catch and CPUE fluctuated considerably. The total annual catch varied between 99,800 and 251,785 metric tons (CV=24.8%) and CPUE varied between 4.2 and 8.6 kg/tan (CV=26.6%).

CPUE also varied by season, with a peak during summer (June-August, usually July) except for 1989 when the high CPUE occurred during October-December (Table 1). Fishing effort was also high in summer (June-September ; Yatsu *et al.*, 1993, 1994). Therefore, the July CPUE for the entire fishing ground (170°E-145°W) and in the western area (170°E-180°) were highly correlated with the annual CPUE ($r=0.88$, $P<0.01$ and $r=0.86$, $P<0.01$ respectively, Fig. 3).

2. Correlation of commercial CPUE to sea surface temperature

Neon flying squid CPUE in July was plotted by one-degree latitude and longitude block together

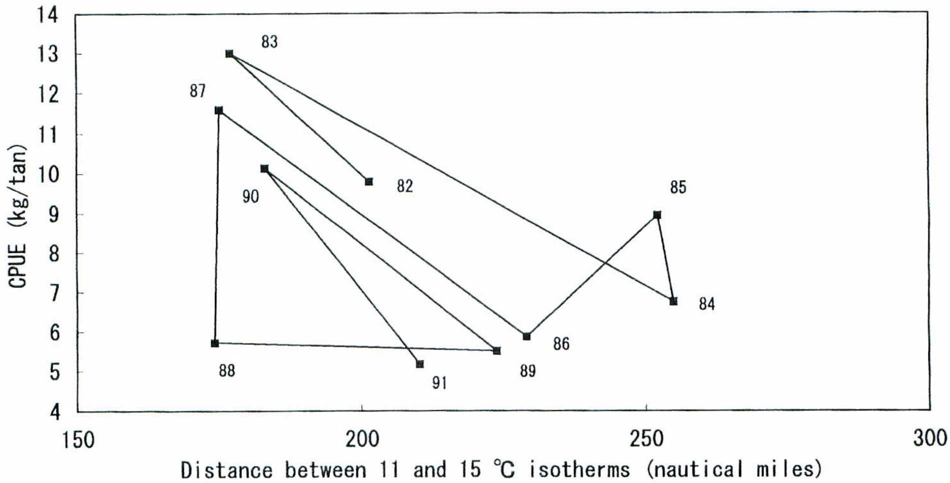


Fig. 5. Relation between average distance between 11°C and 15°C sea surface temperatures (170°E-150°W) and neon flying squid CPUE in the Japanese squid driftnet fishery during July 1982-91.

with sea surface temperature (SST) distribution (Fig. 4). It appears from July CPUE in Table 1 and Fig. 4 that 1983 and 1987 were good fishing years, 1982, 1985 and 1990 were fairly good years and 1984, 1986, 1988, 1989 and 1991 were poor fishing years. The 15°C isotherms in July were located between 40°N and 45°N, usually meandering around the central latitudes of the fishing grounds, and the locations were not correlated to the CPUE of the same month.

Gong *et al.* (1990 and 1993b) pointed out that meandering of 15°C and 20°C isotherms and thermal gradient between them affect the CPUE in the Korean squid driftnet fishery in the northwestern Pacific. The degree of gradient, however, is not related to CPUE in the east-west direction within the fishing grounds; *i.e.*, SST isotherms were more concentrated in the western area whereas CPUE is often higher in the eastern area (Fig. 4).

To examine the effect of SST gradient, the distance between 11°C and 15°C isotherms at every five degree longitudes between 170°E and 150°W was averaged year by year and plotted against the July CPUE (Fig. 5). The 11°C isotherm was assumed to be a barrier to limit the northern distribution of neon flying squid, although the lowest SST of occurrences was reportedly 9°C (Ogura and Takagi, 1987). The average distance indicated a negative correlation with CPUE though the relationship was rather weak ($r=-0.47$, $P=0.72$ for all years; $r=-0.67$, $P=0.05$ by excluding the 1988 data). Namely, strong SST gradient between 11°C and 15°C was observed in good fishing years and gradient was weak in poor fishing years except for 1988 (Fig. 5). Although latitude of the 15°C isotherm at 170°E and 175° 30'E in 1988 was near the mean value of 1978-91 (Pearcy *et al.*, 1993; Ignell *et al.*, 1995; see also Fig. 4), subsurface data indicated the coolest condition in 1988, *i.e.*, the Subarctic Frontal Zone occupied the southernmost position in 1988 (Ignell *et al.*, 1995) and temperature and salinity at 200m depth were extremely low (Figs. 7 and 8). Neon flying squid

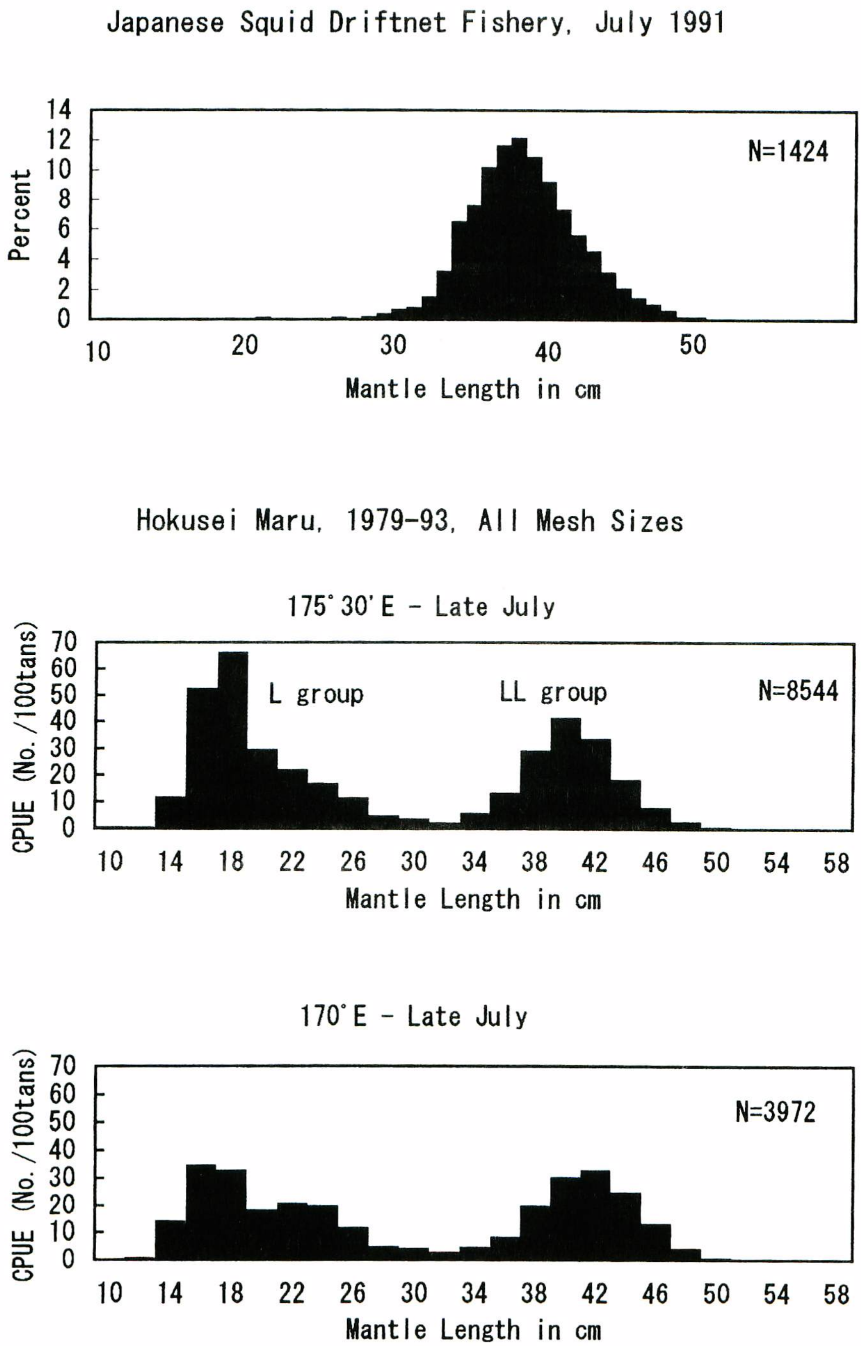


Fig. 6. Mantle length compositions of neon flying squid taken by the Japanese squid driftnet fishery in July 1991 (top) and by the Hokusei Maru's non-mesh-selective-nets at 175°30'E (middle) and 170°E (bottom) in late July, 1979-93.

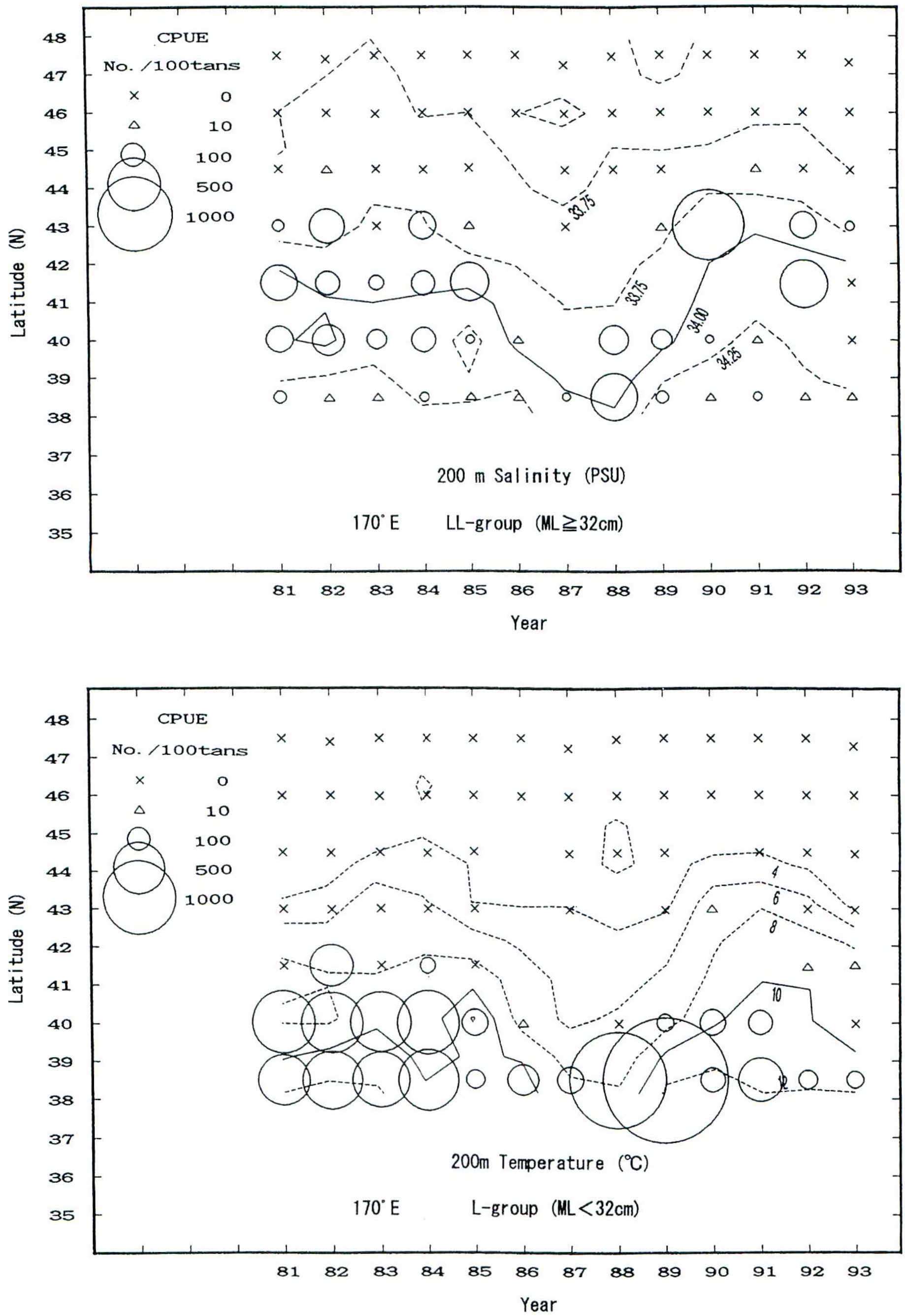


Fig. 7. Interannual variation of neon flying squid CPUE at each site of the Hokusei Maru's survey and 200m depth water temperature and salinity distributions at 170°E in late July, 1981-1993. Top, LL group (larger than 32cm ML) and salinity distributions; bottom, L group and temperature distributions.

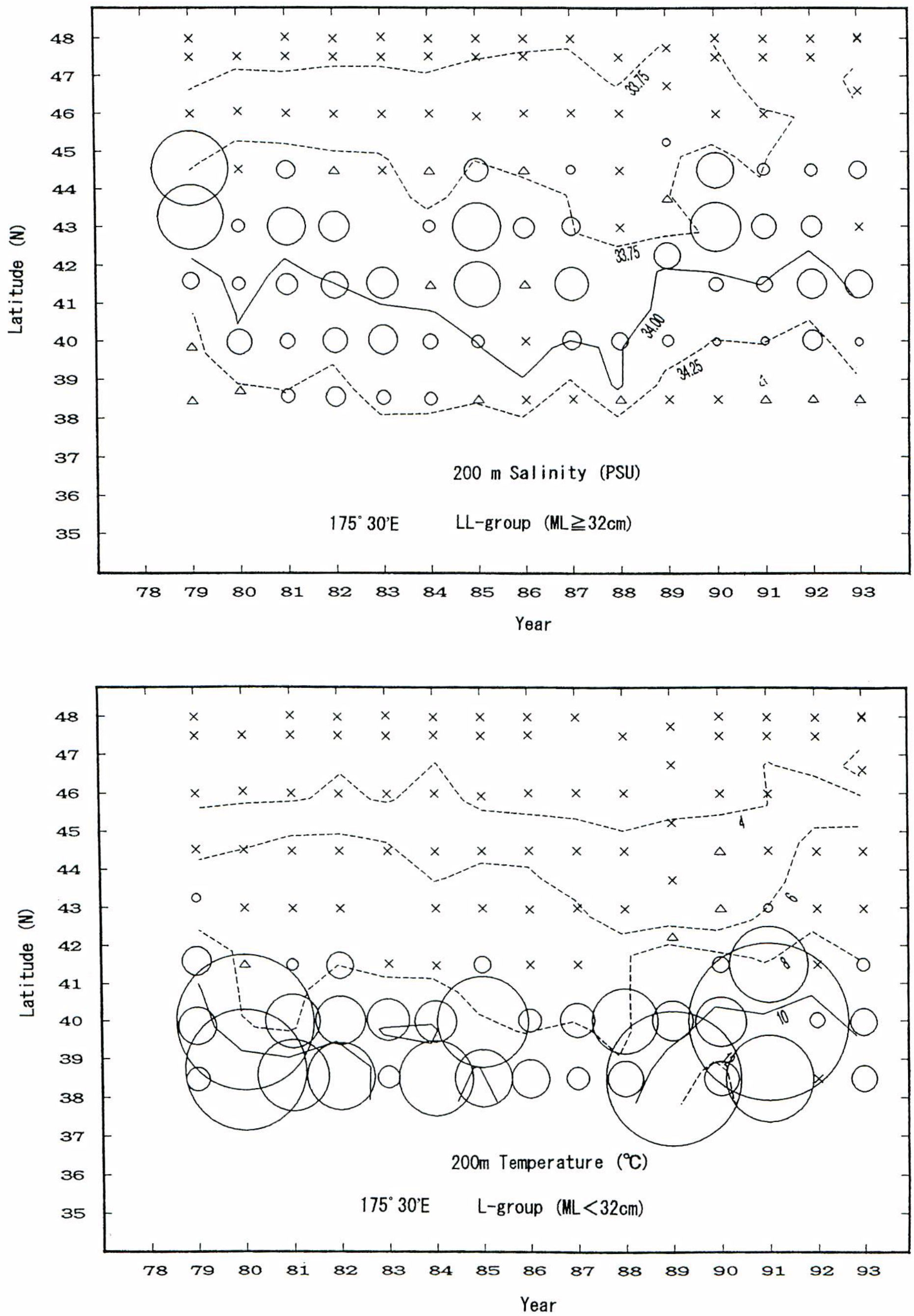


Fig. 8. Interannual variation of neon flying squid CPUE at each site of the Hokusei Maru's survey and 200m depth water temperature and salinity distributions at 175°30'E in late July, 1979-1993. Top, LL group and salinity distributions; bottom, L group and temperature distributions. CPUE legends are shown in Fig. 7.

undergo diel vertical migration between surface (depth <40m) at night and midwater (160m-300m) in daytime (Nakamura, 1994). Since the day-light hours are much longer than night in summer, the horizontal distribution of flying squid may be more strongly affected by temperature and salinity at midwater layers than those at the sea surface.

Although, the northern boundary of the eastern fishing grounds (170°W-145°W) was shifted from 42°N to 43°N in 1989 (Yatsu *et al*., 1993, 1994), this did not appear to affect the relationship.

The commercial CPUE are considered to be affected by abundance of squid (recruitment level), availability of squid to the fishery, amount of fishing effort and gear efficiency. If the SST gradient is strong, squid are expected to be concentrated near the northern barrier in the course of northward migration. Since fishing effort and gear design is thought to be relatively stable after 1983 (Yatsu *et al*., 1993, 1994), variability of CPUE within strong and weak SST gradient years may be attributed to different recruitment levels. Among weak SST gradient years, annual CPUE decreased from 1984 and 1985 to 1986, 1989 and 1991, suggesting the effect of fishing.

3. Mantle length distributions

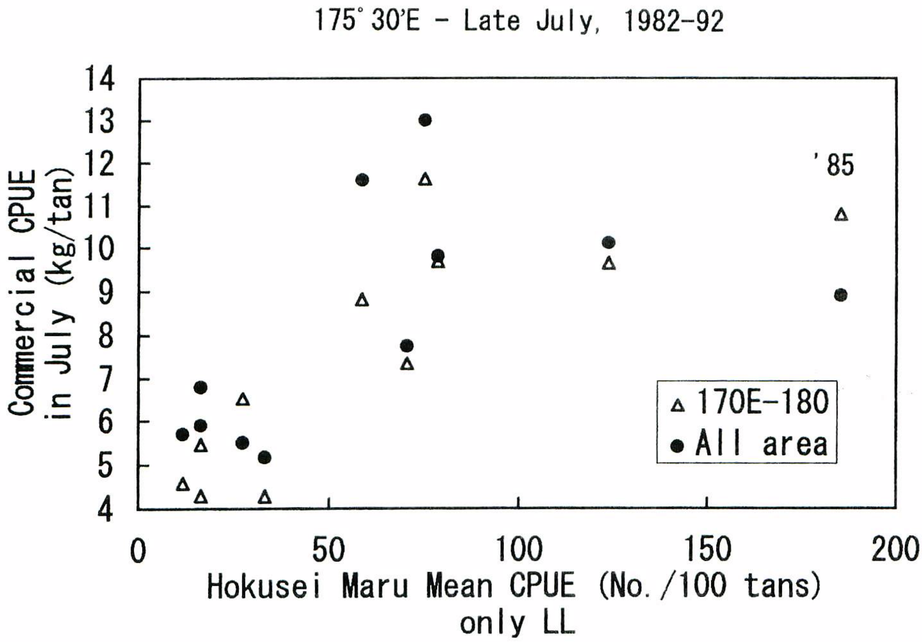
Mantle length compositions from JSDF and Hokusei Maru's research are shown in Fig. 6. While the commercial fishery almost exclusively harvested large squid (LL group), Hokusei Maru's non-selective nets collected a much broader size range of squid from 12 to 50 cm which consisted of both LL group and other groups, probably mainly L and additionally S groups (see Murata and Hayase, 1993) for both 170° 30′ E and 175°E longitudes. Kubodera and Yoshida (1981) indicated that the length composition of neon flying squid taken by the non-selective nets of the Hokusei Maru could represent size composition of the squid population.

4. Distribution of neon flying squid in the Hokusei Maru data

In Figs. 7 and 8, CPUE of LL and other groups (from here called as L group) at each site are shown with respect to temperature and salinity at 200m depth. The LL group appear to occupy more of the northern sites than the L group at both longitudes. The northern boundaries of their distribution varied from year to year, though there are considerable number of missing sites along 170°E.

Distributions of water temperatures and salinity at 200 m depth were constructed from CTD data and were superimposed on CPUE distribution (Figs. 7 and 8). Along 170°E, the latitude of the Subarctic Boundary (defined as the vertical ascent of the 34.00 PSU) varied from year to year. From Fig. 7, this boundary was located between 41°N and 42°N during 1981-85, shifted to the south of 40°N during 1986-88, moved north in 1989, and was located north of 42°N after 1989. This variation was basically identical in the temperature distribution (*e.g*., 8°C isotherm in Fig. 7 bottom). The interannual variations in temperature and salinity at 175° 30'E indicated a similar pattern as at 170°E during 1981-93 (Fig. 8).

These temperature and salinity distributions were well correlated with flying squid distribution (Figs. 7 and 8). Higher CPUE of the LL group were concentrated between 6°C and 9°C, and 33.75-34.00 PSU at the 200m depth layer. Distribution of the L group was almost confined to 8°C and



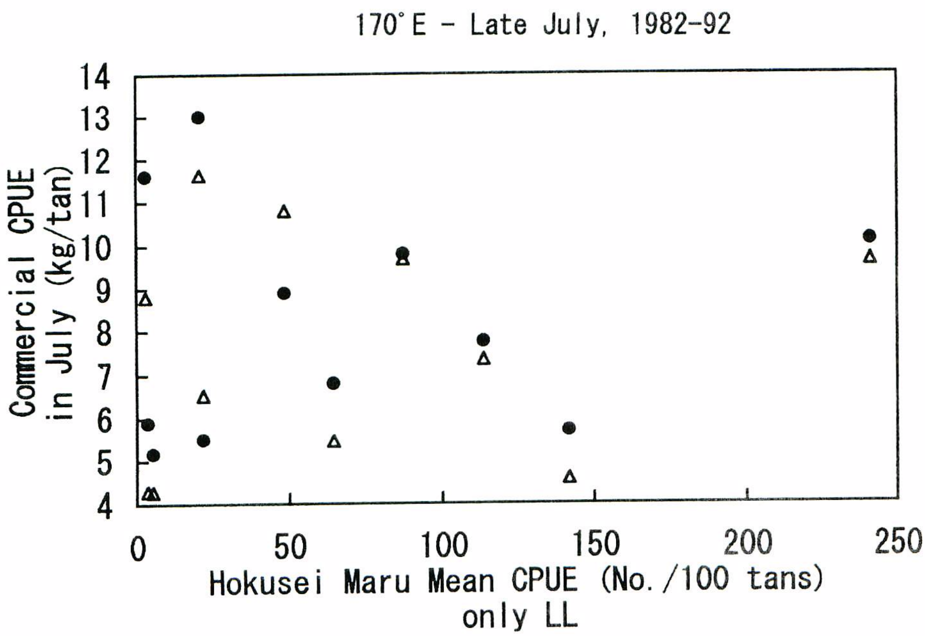


Fig. 9. Relation between neon flying squid CPUE of the Hokusei Maru's driftnet in July at 175°30'E and 170°E and of the commercial fishery in July for entire (●) and western fishing grounds (△).

warmer or south of the Subarctic Boundary. The annual abundance of flying squid, however, seemed to have no direct relation with the temperature and salinity distribution.

Based on the Hokusei Maru data along 175° 30'E, Ignell *et al.* (1995) found that SST and oceanographic zones were generally well correlated to species ranges or communities. The northern range of neon flying squid, however, was uncorrelated with any of the oceanographic parameters. For the latter, Ignell *et al.* (1995) pointed out the presence/absence data are subject to uncertainties raising partly from sampling effort. In the present paper, northern boundaries of both LL and L groups were also not exactly corresponded to particular isotherms or isohalines at 200m depth (Figs. 7 and 8). The high CPUE of LL and L groups, however, were confined to the above temperature and salinity ranges. CPUE data, therefore, seems to be more appropriate for studying geographic distributions of neon flying squid.

5. Relation between commercial and Hokusei Maru CPUE

Annual mean CPUE of the Hokusei Maru data was calculated by dividing the total catch in number of squid of the LL group, which occurred south of 48°N, by the corresponding fishing effort, and then it was compared with the commercial CPUE in July (Fig. 9). The Hokusei Maru's mean CPUE at 175° 30'E was highly correlated with commercial CPUE of the western fishing area (170° E-180°, $r=0.79$, $P<0.01$) or moderately related with that of the entire fishing area (170°E-145°W, $r=0.53$, $P>0.05$). The Hokusei Maru's mean CPUE at 170°E had no relation with the commercial CPUE ($r=0.08$, $P>0.05$ for the entire area, $r=0.15$, $P>0.05$ for the western area). Probably owing to stormy weather, Hokusei Maru had missed stations at 170°E in the late 1980's where good catches of the LL group could have been obtained. This deficiency of data may have brought this anomalous result.

The commercial CPUE in 1985 was considerably higher in the western area than in the entire fishing ground (Figs. 4 and 9), while in usual years CPUE was lower in the western area. The Hokusei Maru's CPUE in 1985 was extremely high at 175° 30'E and good commercial CPUE was recorded also at this longitude (Fig. 4). Therefore, 1985 was considered to be an unusual year though the reason is unclear.

While the commercial CPUE are affected by abundance (recruitment level), availability of squid to the fishery as well as weather condition, the Hokusei Maru's CPUE may be considered to represent abundance because of the fixed locations covering entire latitudinal range of LL group in summer.

Conclusion

Distribution and availability of neon flying squid to the driftnet fishery in the Central North Pacific is strongly affected by water temperature and salinity structures around the Subarctic Boundary. Importance of Hokusei Maru's research activities for monitoring oceanographic and biological conditions should be stressed, since it is effective for studying interannual variation in distribution and abundance of pelagic nekton and possibly for future fishery management (see also

Ignell *et al*., 1995). It is also desired to expand similar surveys, such as the Osyoro Maru cruises since 1980 and the Wakatake Maru cruises since 1991 along the date line from subtropical to subarctic waters in June and July (Hokkaido University 1981–94 ; Ishida *et al*., 1991) in order to improve the monitoring accuracy and for developing a better understanding of the geographic and intraannual variability in abundance and biology of pelagic nekton as well.

Acknowledgments

We thank William Shaw of the Pacific Biological Station, Canada, for providing computer-readable files of Hokusei Maru's data set, 1978-89, and also for critical reading of the manuscript. We thank Toshio Kasuya, Ziro Suzuki, Kiyoshi Wakabayashi and Satsuki Matsumura of our institute for critical reading of the manuscript. We also thank Professor Yasunori Sakurai of the Hokkaido University for providing useful information on the Hokusei Maru's data.

Literature cited

BURKE, W.T., M. FREEBERG and E.L. MILES 1994 : United Nations Resolutions on driftnet fishing : an unsustainable precedent for high seas and coastal fisheries management. *Ocean Devel. Int. Law*, 25, 127-186 (1994).

Fisheries Agency of Japan 1984-92 : Catch and effort statistics for the Japanese squid driftnet fishery in the North Pacific. Documents submitted to the Int. Nat. North Pacific Fish. Comm.

Fisheries Agency of Japan 1993 : Catch and effort statistics for the Japanese squid driftnet fishery in the North Pacific in 1992. unpublished manuscript, 38pp.

GONG, Y., Y.S. KIM, and D.H. AN 1990 : Abundance of flying squid in relation to oceanographic conditions in the North Pacific. *Bull. Nat. Fish. Res. Dev. Agency*, 44 : 59-66. In Korean.

GONG, Y., Y.S. KIM and S.J. HWANG 1993a : Outline of the Korean squid gillnet fishery in the North Pacific. *Bull. Int. Nat. North Pacific Fish. Comm*., 53 : 45-69.

GONG, Y., Y.S. KIM and D.H. AN 1993b : Abundance of neon flying squid in relation to oceanographic conditions in the North Pacific. *Bull. Int. Nat. North Pacific Fish. Comm*., 53 : 191-204.

Hokkaido University 1980-94 : Data record of oceanographic observations and exploratory fishing. Fac. Fish., Nos. 22-37.

IGNELL, S.E., S.R. CARLSON and R.A. RUMBAUGH 1995 : Variability in frontal boundaries, temperatures, and the geographic ranges of species and pelagic marine communities along 175° 30'E, 1978-91. pp. 667-674. In : Climate change and northern fish populations (Beamish, R.J. ed.), *Can. Spec. Publ. Fish. Aquat. Sci*., 121.

ISHIDA, Y., N.D. DAVIS and K. TADOKORO 1991 : Cooperative Japan-U.S. high seas salmonid research in 1991 : summary of research on board the Japanese research vessel Wakatake Maru, 4 June to 23 July. Document submitted to the Int. Nat. North Pacific Fish. Comm., 35 pp.

KUBODERA, T. and H. YOSHIDA 1981 : The gill-net mesh selectivity for flying squid, *Ommastrephes bartrami* (LESUEUR). *Res. Inst. North Pacific Fisheries, Hokkaido Univ*., Special Volume :

181-190.

MURATA, M. 1990 : Oceanic resources of squids. *Mar. Behav. Physiol.*, 18 : 19-71.

MURATA, M. and S. HAYASE 1993 : Life history and biological information on flying squid (*Ommastrephes bartrami*) in the North Pacific Ocean. *Bull. Int. Nat. North Pacific Fish. Comm.*, 53 : 147-182.

NAKAMURA, Y. 1994 : Methods of field observation for squid behavior with an emphasis on biotelemetry. pp. 109-117. In Ikarui-shigen-gyokaikyou-kentou-kaigi-kenkyu-houkoku (Proceedings of the annual meeting for squid resources and oceanographic conditions in 1992), Nat. Res. Inst. Far Seas Fish., Shimizu. In Japanese.

OGURA, M. and K. TAKAGI 1987 : Difference in area of distribution between salmon and flying squid based on data collected by Japanese salmon research vessels, 1983-86. Document submitted to the Int. Nat. North Pacific Fish. Comm., 21 pp.

PEARCY, W.G., J.P. FISHER and M.M. YOKLAVICH 1993 : Biology of the Pacific pomfret (*Brama japonica*) in the North Pacific Ocean. *Can. J. Aquat. Sci.*, 50 : 2608-2625.

SEKI, M.P. 1993 : The role of neon flying squid, *Ommastrephes bartrami*, in the North Pacific pelagic food web. *Bull. Int. Nat. North Pacific Fish. Comm.*, 53 : 207-215.

TAKAGI, K. 1975 : A non-selective salmon gillnet for research operations. *Bull. Int. Nat. North Pacific Fish. Comm.*, 32 : 13-33.

YATSU, A., K. HIRAMATSU and S. HAYASE 1993 : Outline of the Japanese squid driftnet fishery with notes on the bycatch. *Bull. Int. Nat. North Pacific Fish. Comm.*, 53 : 5-24.

YATSU, A., K. HIRAMATSU and S. HAYASE 1994 : A review of the Japanese squid driftnet fishery with notes on the cetacean bycatch. *Rep. Int. Whal. Commn.* Spec. Issue, 15 : 365-379.

1982年～1992年の中部北太平洋における
アカイカ豊度と水温塩分分布の経年変動

谷 津 明 彦・渡 邊 朝 生

中部北太平洋においてアカイカ（*Ommastrephes bartrami*）は1978～1992年の間に日本のいか流し網漁業の対象とされた。この漁業によるアカイカの年間の単位漁獲努力量当たり漁獲量（CPUE，kg/反）は4.2～8.6と約2倍の変動を示した。一方，北海道大学練習船北星丸は1978年から170°E と175° 30'E の北太平洋において毎年7月を中心に亜熱帯域北部～亜寒帯域の同一定点群で海洋観測と流し網調査を継続している。北星丸の175° 30'E における大型アカイカ（LL 群）の平均 CPUE といか流し網漁業の盛漁期である7月の CPUE を経年的に比較したところ両者は高い相関（r＝0.79，P＜0.01）を示した。また，北星丸調査および流し網漁業ともアカイカの CPUE 分布は亜寒帯前線付近の水温や塩分分布と良く対応した。アカイカの索餌期（亜熱帯北部～亜寒帯南部）における分布と豊度のモニタリングの可能性と重要性も論じた。