NPAFC
Doc. 426
Rev.

Changes in Abundance and Biological Character of Pacific Salmon in the North Pacific Ocean from 1972 to 1998

by

Yukimasa Ishida and Tomonori Azumaya

Hokkaido National Fisheries Research Institute
116 Katsurakoi, Kushiro, Hokkaido 085-0802, Japan

Submitted to the
NORTH PACIFIC ANADROMOUS FISH COMMISSION

by

JAPAN
October 1999

THIS PAPER MAY BE CITED IN THE FOLLOWING MANNER:
Ishida, Y., and T. Azumaya. 1999. Changes in abundance and biological character of Pacific salmon in the North Pacific Ocean from 1972 to 1998. (NPAFC Doc.426). Hokkaido National Fisheries Research Institute, 116 Katsurakoi, Kushiro, Hokkaido 085-0802, Japan. 15 p.

Changes in Abundance and Biological Character of Pacific Salmon in the North Pacific Ocean from 1972 to 1998

Yukimasa Ishida and Tomonori Azumaya

Hokkaido National Fisheries Research Institute

ABSTRACT

Catch-per-unit-effort(CPUE: number of fish caught by 30 tan gillnets), fork length (FL) and gonad somatic index (GSI) of the Pacific salmon caught by research gillnets in the western North Pacific (WNP), Bering Sea (BS), and eastern North Pacific (ENP) in July from 1972 to 1998 were compared. CPUE of sockeye and chum salmon (less than 100 fish per 30 tans) was higher in BS and ENP than in WNP, especially the CPUE in BS was high in the late 1970s to early 1980s and in 1990s. Pink salmon CPUE (less than 500 fish per 30 tans) increased in BS in odd years after 1989, although it was stable in WNP and ENP. Coho salmon were abundant in WNP and ENP, and chinook salmon were abundant in BS, but their CPUEs were less than 50 fish per 30 tans. FL of sockeye salmon decreased in BS, but increased in WNP and ENP. For chum salmon, FL of ocean age 1 fish increased, but those of older age groups decreased in WNP and BS. FL of pink salmon decreased both in odd and even year in BS, but not in WNP and ENP. FL of coho salmon decreased in WNP, but increased in ENP. GSI of sockeye salmon was very variable and there was not a specific trend. GSI of chum salmon showed a decreasing trend in recent years in BS. GSI of pink salmon was low in odd years and high in even years in BS. These results indicate that the abundance and biological characters of Pacific salmon changed differently in three waters of the North Pacific Ocean.

INTRODUCTION

Five species of Pacific salmon (sockeye salmon, *Oncorhynchus nerka*; chum salmon, *O. keta*; pink salmon, *O. gorbuscha*; coho salmon, *O. kisutch*; and chinook salmon *O. tshawytscha*) are widely distributed in the North Pacific Ocean and its adjacent seas (French *et al*. 1976; Neave *et al*. 1976; Takagi *et al*. 1981; Godfrey *et al*. 1975; Major *et al*. 1978). Abundance of Pacific salmon increased rapidly after the mid-1970s due to successful fishery management, advance in enhancement activities, and preferable ocean conditions (Beamish and Bouillion 1993; Pearcy 1992). However, the biological characters such as body size and age at maturity changed for some salmon species and stocks (Ishida et al. 1993; Bigler et al. 1996). This study examined the abundance and biological characters of Pacific salmon (*Oncorhynchus* spp.) in three different waters in the North Pacific Ocean using the data collected by Japanese salmon research vessels from 1972 to 1998.

MATERIALS AND METHODS

Historical data collected by Japanese salmon surveys in the North Pacific Ocean from 1972 to 1998 were analyzed in this study. Three major survey waters were used in this study as follows: the western North Pacific (WNP: 30˚-52˚ N, 150˚-175˚ W), the Bering Sea (BS: 55˚-59˚ E, 175˚ E-175˚ W), and the eastern North Pacific (ENP: 175˚ W -140˚ W). Catch per unit effort (CPUE) was defined as mean numbers of fish caught by 30 tans of non-selective gillnets (Takagi 1975) and it was calculated by 2 degree latitude by 5 degree longitude areas and averaged by each survey water. Mean fork lengths (FL) were also calculated by survey waters based on the data collected by non-selective gillnets. Maturity was determined from gonad weights (Takagi 1961; Ito et al. 1974). Gonad somatic index (GSI) including maturing and immature fish for female was calculated by gonad weight divided by body weight.

RESULTS AND DISCUSSION

Abundance

CPUE of sockeye and chum salmon (less than 100 fish per 30 tans) was higher in BS and ENP than in WNP, especially the CPUE in BS was high in the late 1970s to early 1980s and in 1990s (Fig. 1 and Fig. 2). Immature fish were predominant for both sockeye and chum salmon in BS. CPUE of immature chum salmon in BS was lower in odd years and higher in even years. This odd-even year change in chum salmon CPUE may be related to pink salmon (Azumaya and Ishida 1999). Pink salmon CPUE (less than 500 fish per 30 tans) increased in BS in odd years after 1989, although it was stable in other waters (Fig. 3). The sharp increase of pink salmon CPUE in odd years in BS affected the biomass of phytoplankton and macrozooplankton in the subarctic North Pacific (Shiomoto et al. 1997). Coho salmon were abundant in WNP and ENP, and chinook salmon were abundant in BS, but their CPUEs were less than 50 fish per 30 tans (Fig. 4 and Fig. 5).

Fork Length

FL of sockeye salmon decreased in BS, but increased in WNP and ENP (Fig. 6). For chum salmon, FL of ocean age 1 fish increased, but those of older age groups decreased in WNP and BS (Fig. 7). Especially, the decreasing trend was stronger in BS than in WNP. FL of pink salmon decreased both in odd and even year in BS, but not in other waters (Fig. 8). FL of coho salmon decreased in WNP, but increased in ENP (Fig. 9). For chum and pink salmon, the decreasing trends in FL may be partly due to density dependent effect especially in BS (Ishida et al. 1993; Azumaya and Ishida 1999).

Gonad Somatic Index

GSI of sockeye salmon was very variable and there was not a specific trend (Fig. 10). GSI of chum salmon showed a decreasing trend in recent years in BS (Fig. 11). For chum salmon in BS, FL also decreased in recent years. This means that not only GSI (percentage of gonad weight to body weight) but also gonad weight itself decreased in recent years. GSI of pink salmon was low in odd years and high in even years in BS

(Fig. 12). Reduction in body size may result in reduced reproductive success (Helle 1989; Forbes and Peterman 1994). These results indicate that the abundance and biological characters of Pacific salmon changed differently in three waters of the North Pacific Ocean.

ACKNOWLEDGMENTS

We thank the captains, crews, and scientists of research vessels who collected the vast amounts of information used in this study.

REFERENCES

Azumaya, T. and Y. Ishida. 1999. Changes in CPPUE and fork length of pink salmon (*Oncorhynchus gorbuscha*) and chum salmon (*Oncorhynchus keta*) in the subarctic North Pacific Ocean. 30th North Pacific Research Symposium abstact, p.9.

Beamish, R. J., and D.R. Bouillion. 1993. Pacific salmon production trends in relation to climate. Can. J. Fish. Aquat. Sci. 50:1002-1016.

Bigler, B. S., D.W.Welch, and J.H.Helle. 1996. A review of size trends among North Pacific salmon(*Oncorhynchus* spp.). Can. J. Fish. Aquat. Sci. 53:455-465.

Forbes, L.S., and R.M. Peterman. 1994. Simple size-structure models of recruitment and harvest in Pacific salmon (*Oncorhynchus* spp.). Can.J.Fish.Aquat.Sci.51:603-616.

French, R., R.G.Bilton, M.Osako, and A.Hartt. 1976. Distribution and origin of sockeye salmon (*Oncorhynchus nerka*) in offshore waters of the North Pacific Ocean. Int. North Pac. Fish. Comm. Bull. 34: 195 pp.

Godfrey, H., K.A.Henry, and S. Machirori. 1975. Distribution and abundance coho salmon in offshore waters of the North Pacific Ocean. Int. North Pac. Fish. Comm. Bull. 31: 80 pp.

Helle, J.H. 1989. Relation between size-at-maturity and survival of progeny in chum salmon *Oncorhynchus keta* (Walbaum). J.Fish.Biol. 35(Suppl.A):99-107.

Ishida, Y., S.Ito, M.Kaeriyama, S. McKinnell, and K. Nagasawa 1993. Recent changes in age and size of chum salmon (*Oncorhynchus keta*) in the North Pacific Ocean and possible causes. Can. J. Fish. Aquat. Sci. 50: 290-295.

Major, R. L., J.Ito, S.Ito, and H.Godfrey. 1978. Distribution and origin of chinook salmon (*Oncorhynchus tshawytscha*) in offshore waters of the North Pacific Ocean. Int. North Pac. Fish. Comm. Bull. 38:54 pp.

Neave, F., T.Yonemori, and R.G.Bakkala. 1976. Distribution and origin of chum salmon in offshore waters of the North Pacific Ocean. Int. North Pac. Fish. Comm. Bull. 35: 79 pp.

Pearcy, W. G. 1992. Ocean eccology of North Pacific salmonids. Unversity of Washington Press, Seattle, Washington.

Shiomoto, A., K.Tadokoro, K.Nagasawa, and Y.Ishida. 1997. Trophic relations in the subarctic North Pacific ecosystem: possible feeding effect from pink salmon. Mar. Ecol. Prog. Ser. 150: 75-85.

Takagi, K., K.V.Aro, A.G.Hartt, and M.B.Dell. 1981. Distribution and origin of pink salmon (*Oncorhynchus gorbuscha*) in offshore waters of the North Pacific Ocean. Int. North Pac. Fish. Comm. Bull. 40:195 pp.

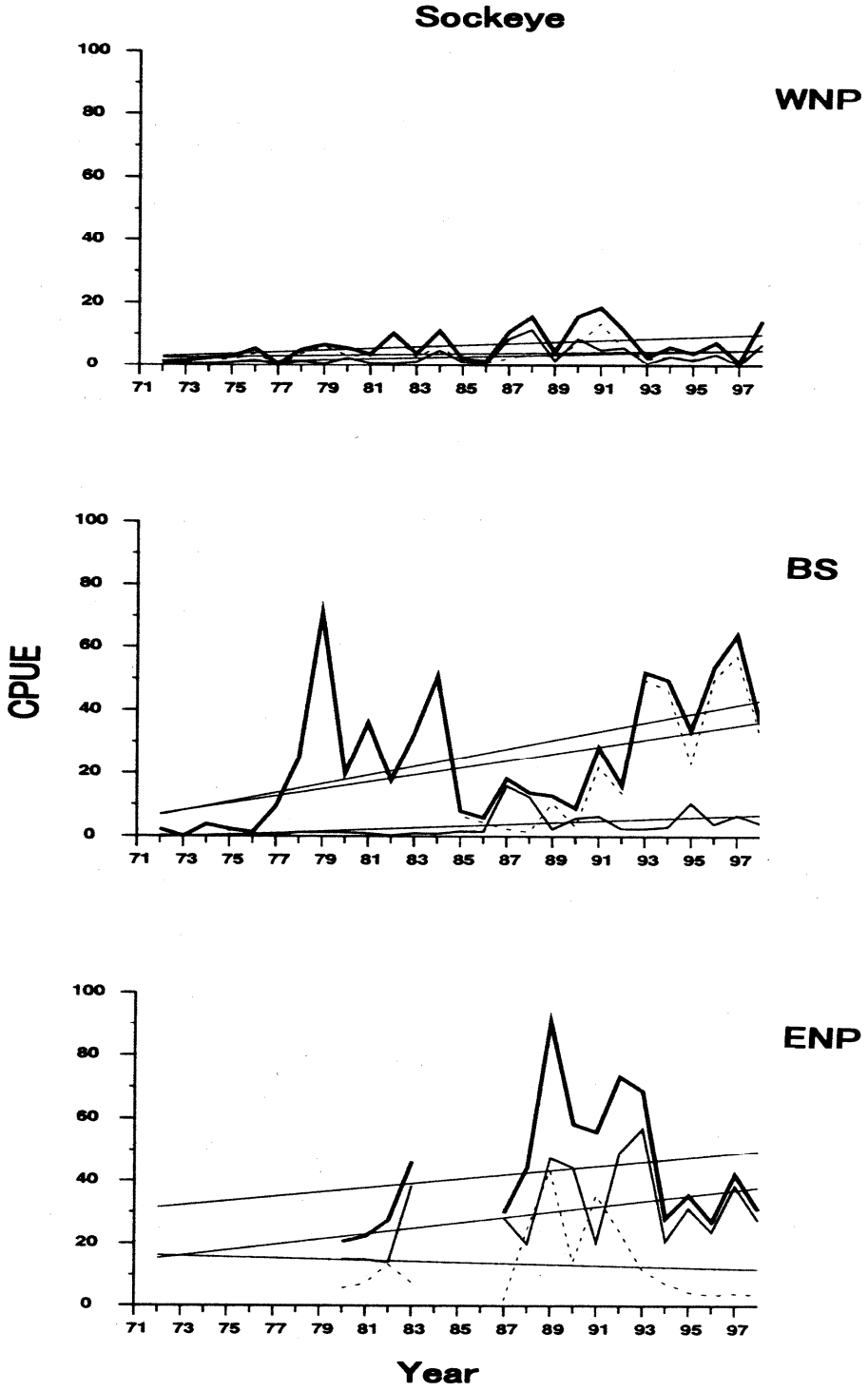

Fig. 1. Changes in CPUE (number of fish caught by 30 tan research gillnets) of sockeye salmon in the western North Pacific (WNP), Bering Sea (BS), and eastern North Pacific (ENP) in July from 1972 to 1998. -:Total, -:maturing, …:immature

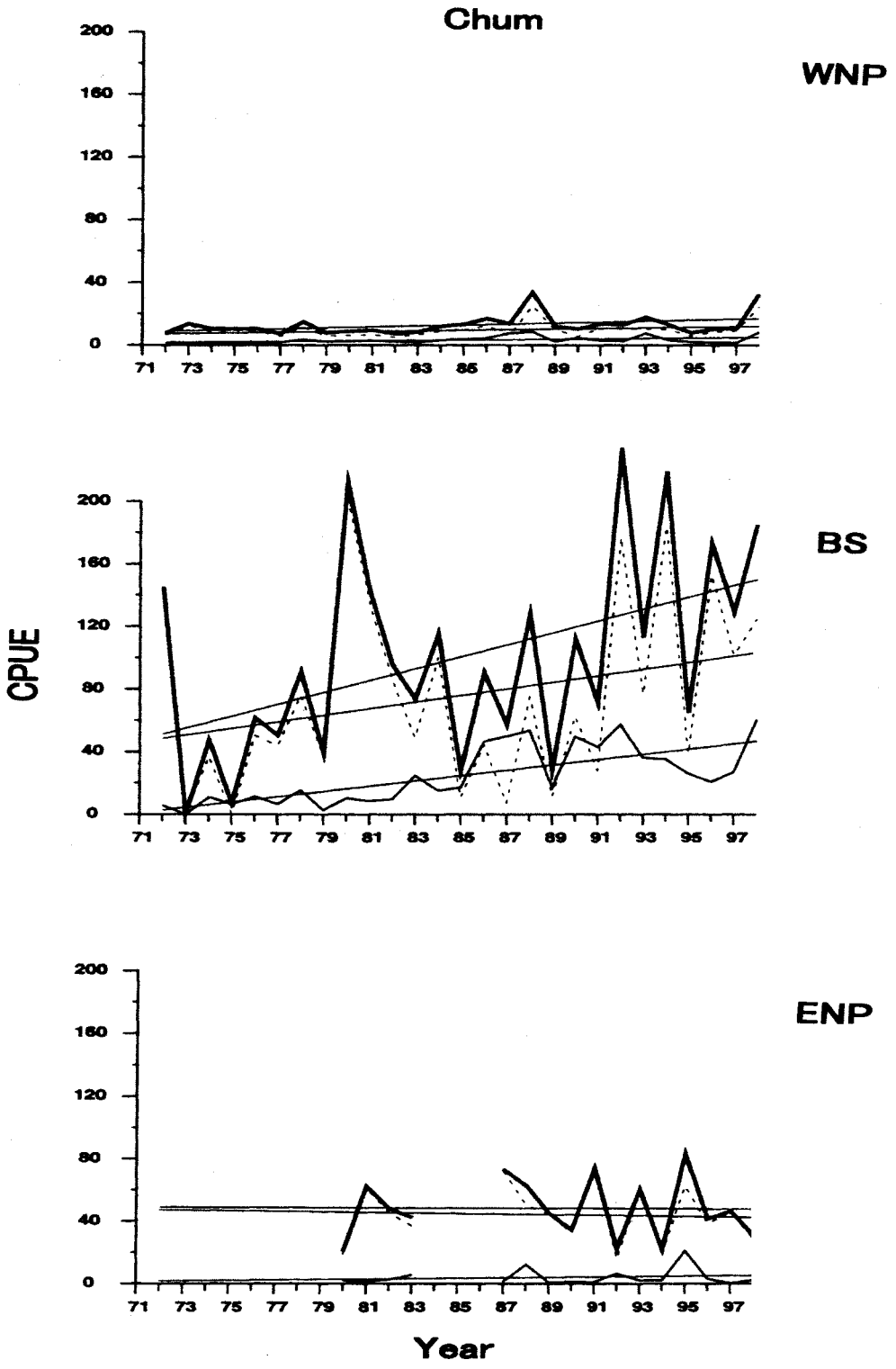

Fig. 2. Changes in CPUE (number of fish caught by 30 tan research gillnets) of chum salmon in the western North Pacific (WNP), Bering Sea (BS), and eastern North Pacific (ENP) in July from 1972 to 1998. -:Total, -:maturing, …:immature

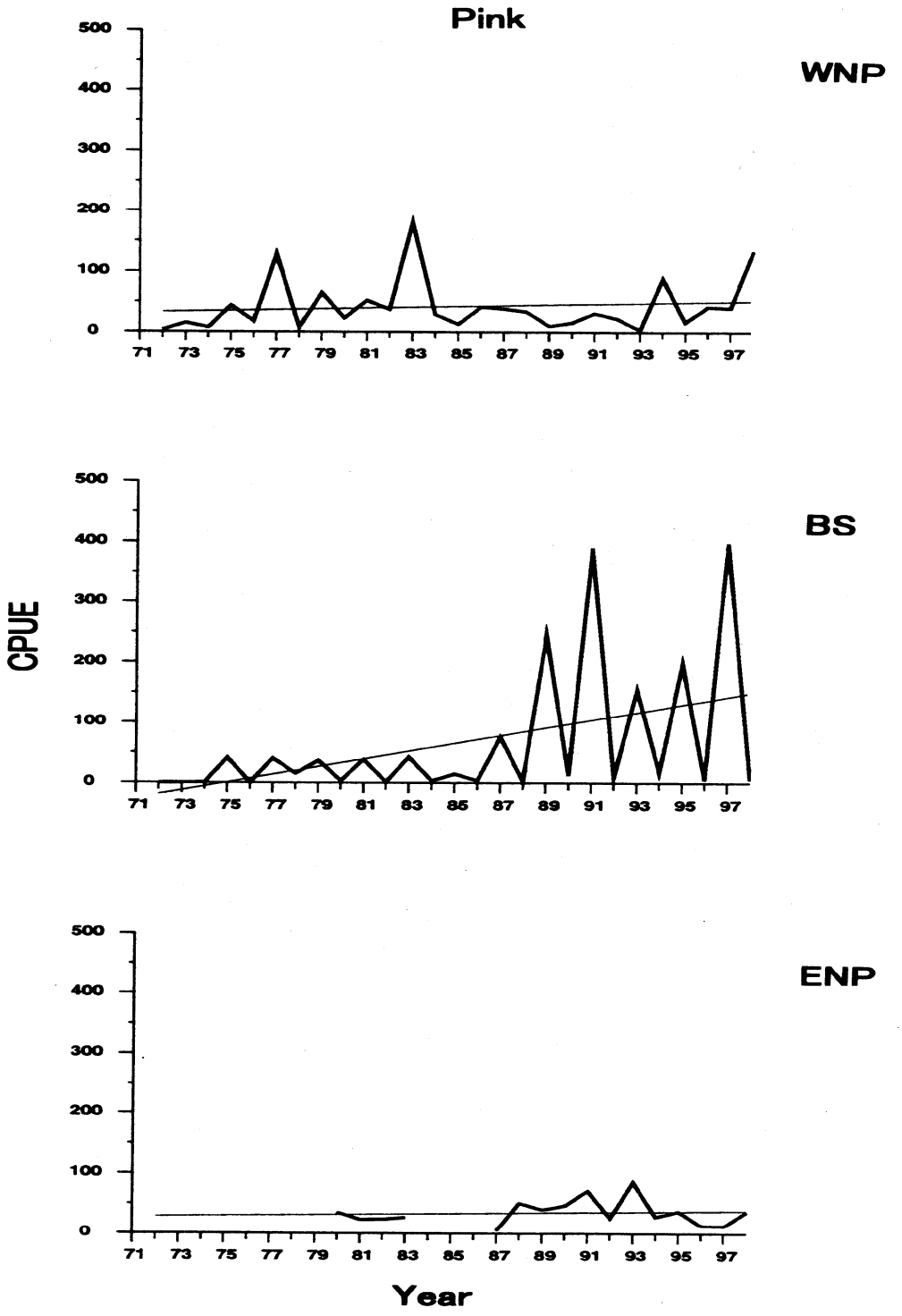

Fig. 3. Changes in CPUE (number of fish caught by 30 tan research gillnets) of pink salmon in the western North Pacific (WNP), Bering Sea (BS), and eastern North Pacific (ENP) in July from 1972 to 1998.

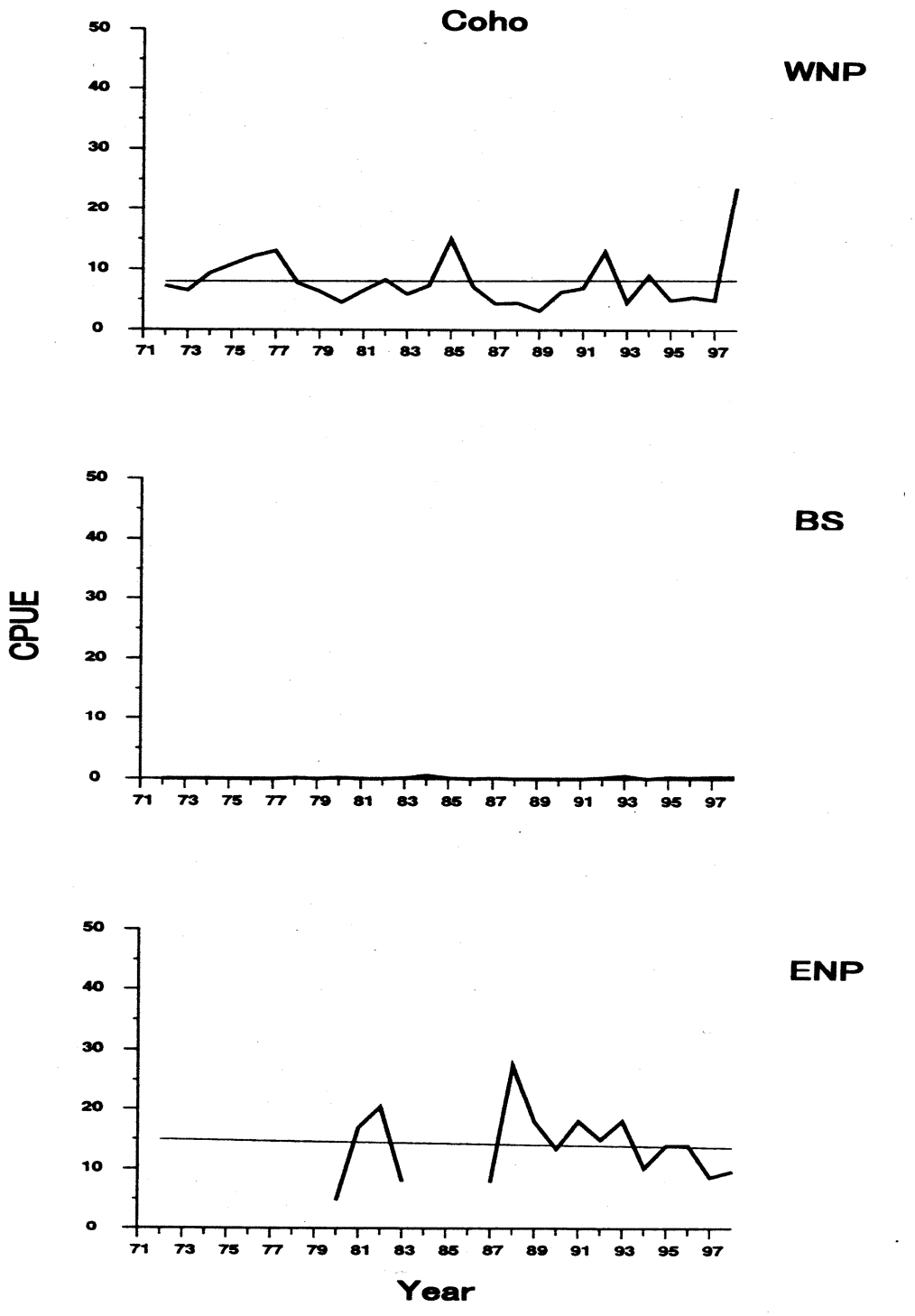

Fig. 4. Changes in CPUE (number of fish caught by 30 tan research gillnets) of coho salmon in the western North Pacific (WNP), Bering Sea (BS), and eastern North Pacific (ENP) in July from 1972 to 1998.

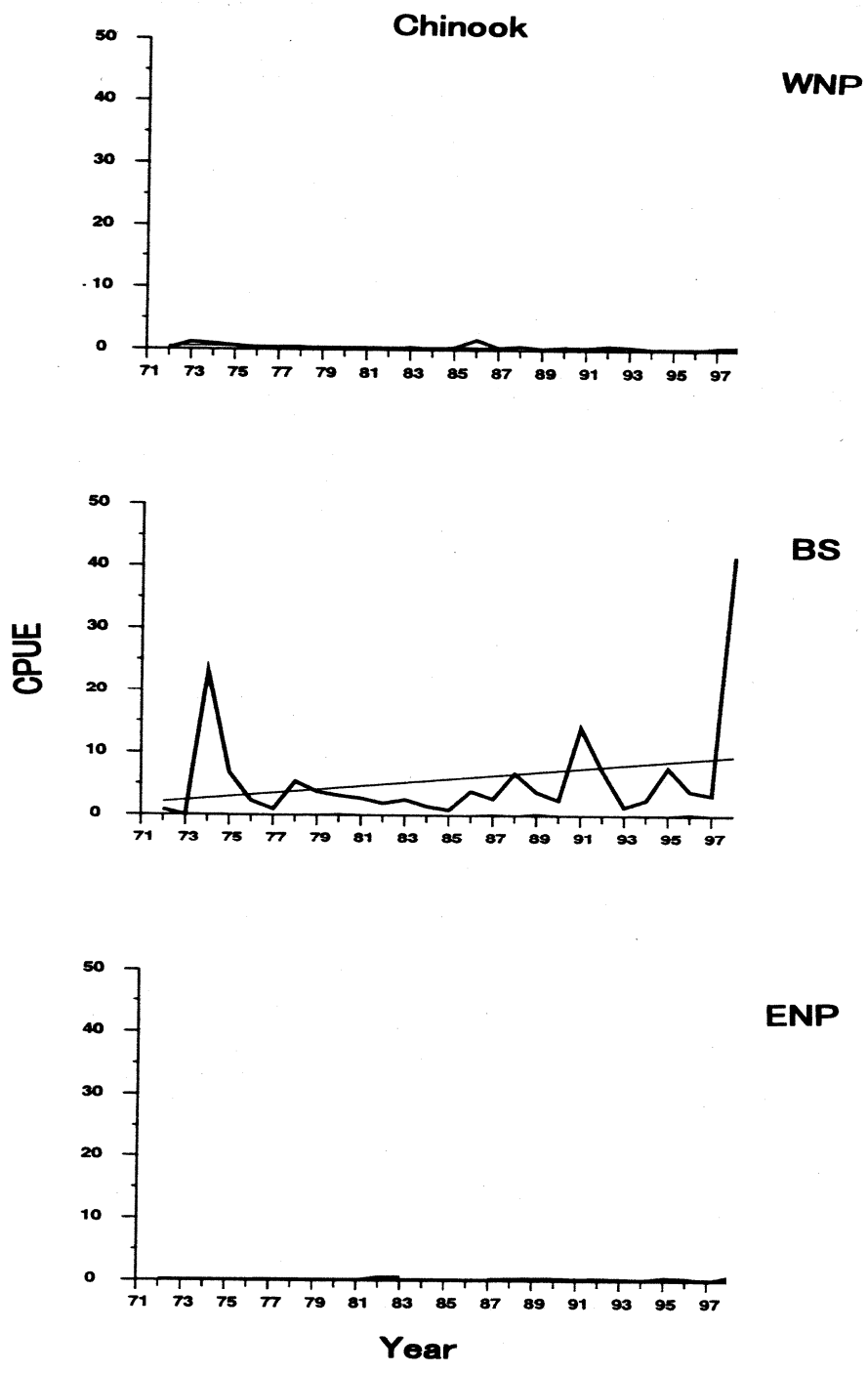

Fig. 5. Changes in CPUE (number of fish caught by 30 tan research gillnets) of chinook salmon in the western North Pacific (WNP), Bering Sea (BS), and eastern North Pacific (ENP) in July from 1972 to 1998.

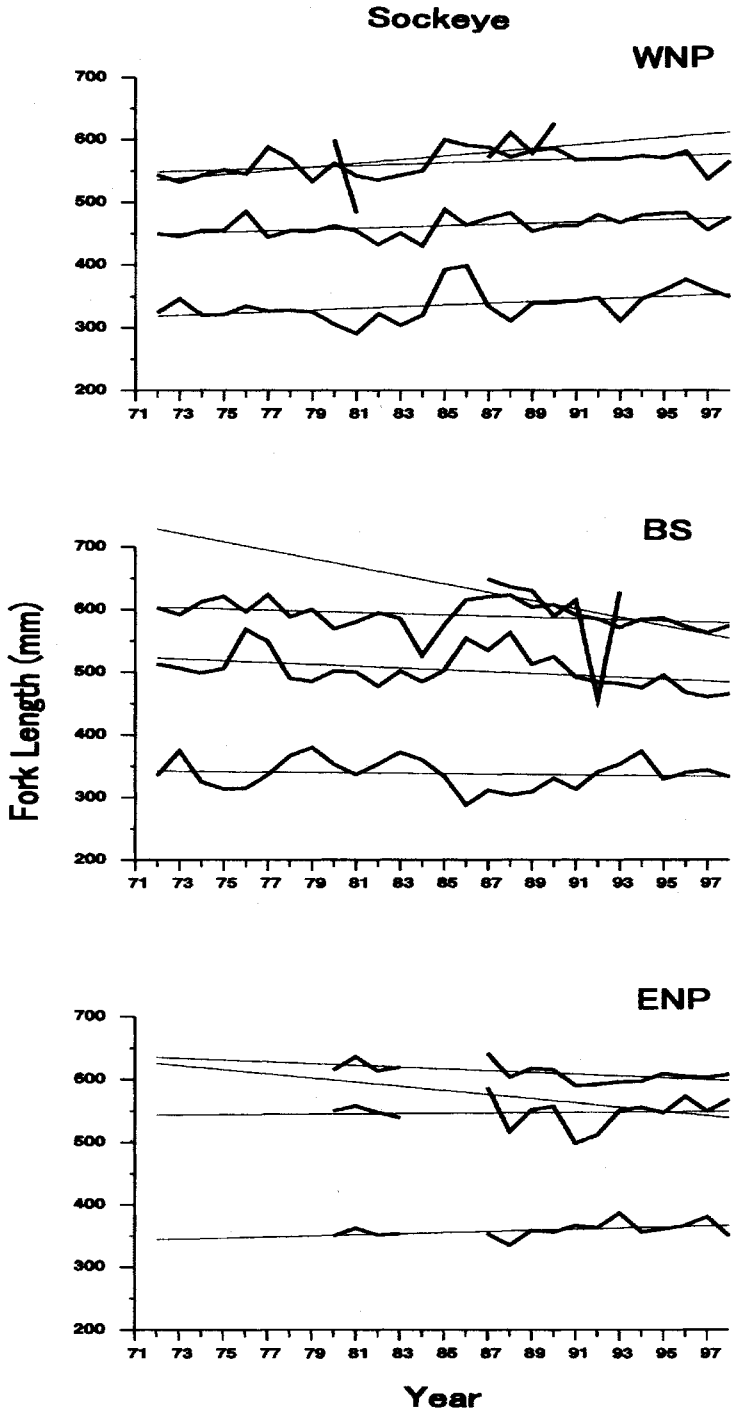

Fig. 6. Changes in fork length of sockeye salmon in the western North Pacific (WNP), Bering Sea (BS), and eastern North Pacific (ENP) in July from 1972 to 1998. Ocean age .1 to .3

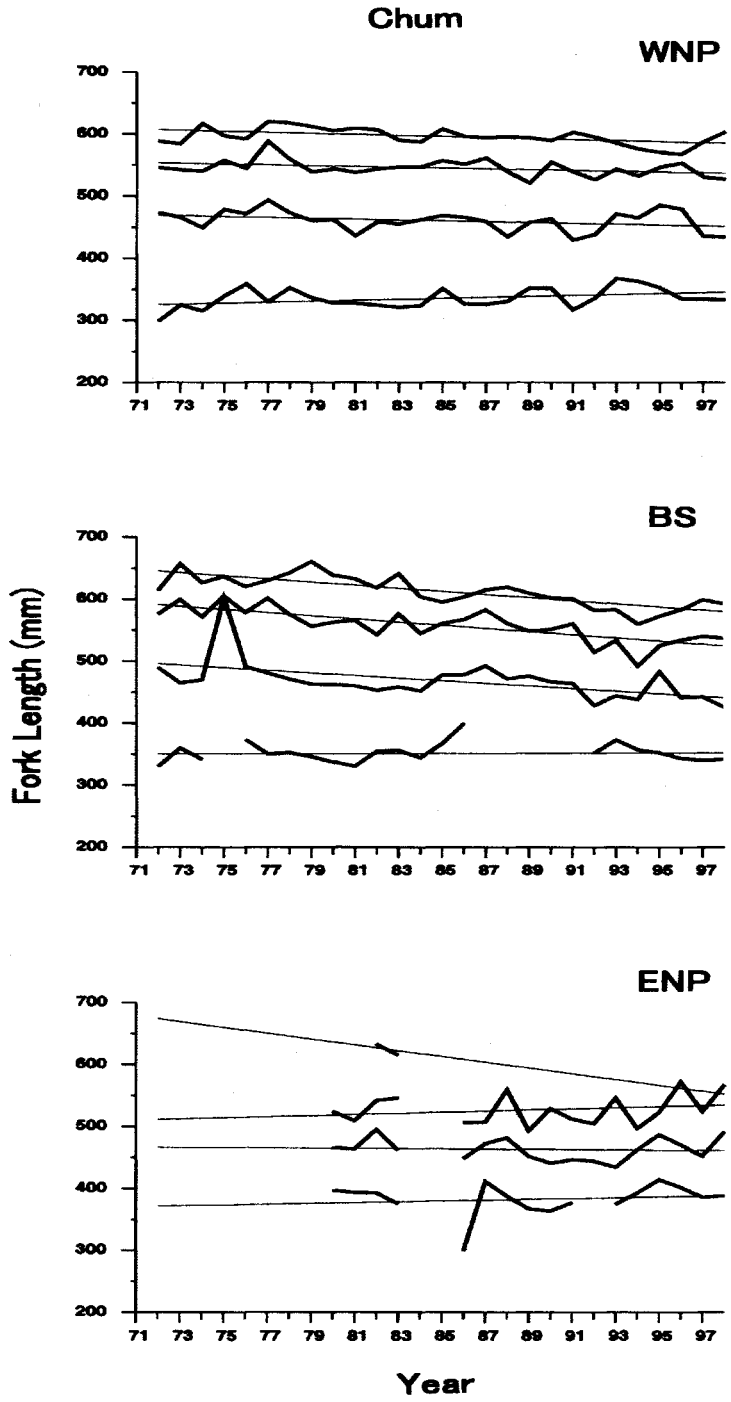

Fig. 7. Changes in fork length of chum salmon in the western North Pacific (WNP), Bering Sea (BS), and eastern North Pacific (ENP) in July from 1972 to 1998. Ocean age .1 to .4.

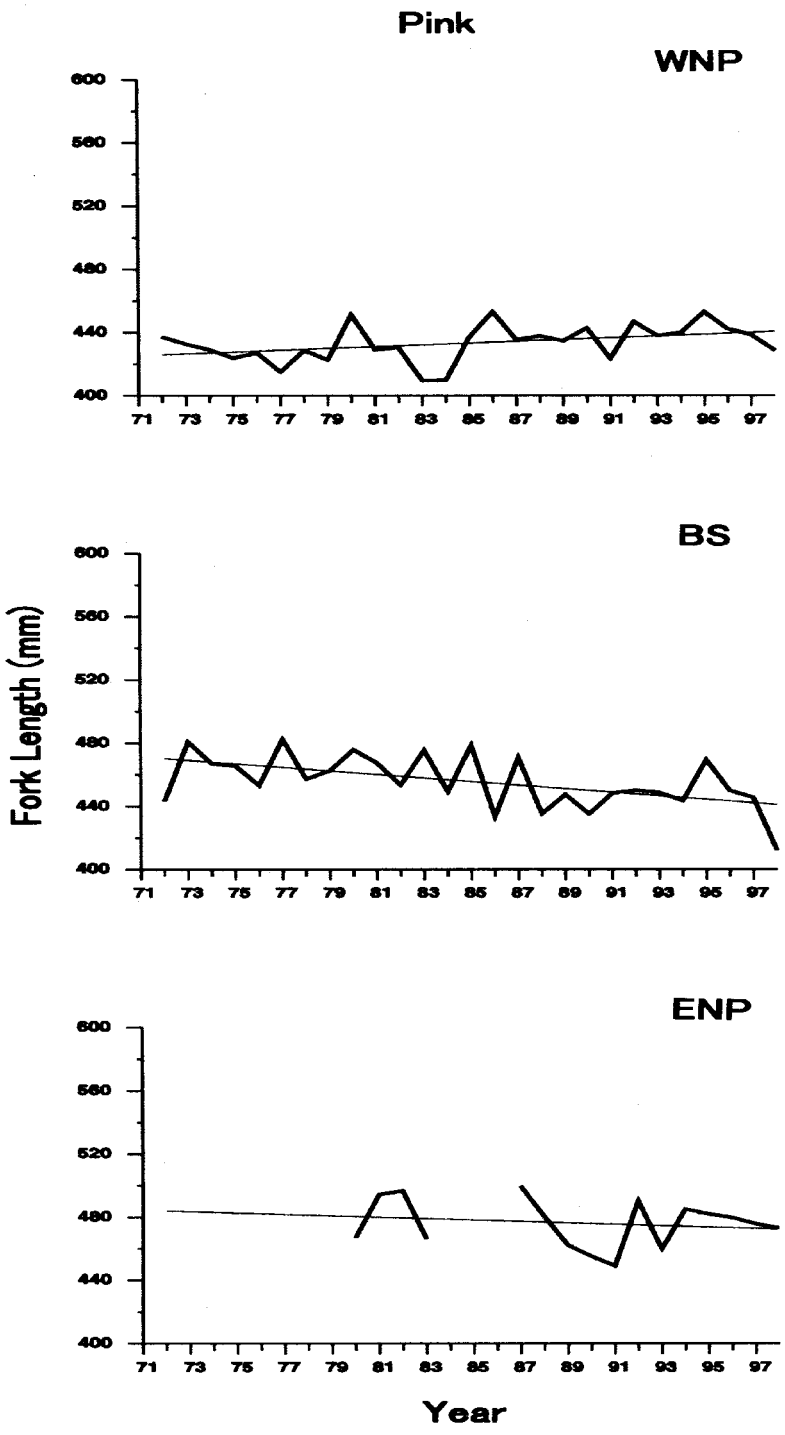

Fig. 8. Changes in fork length of pink salmon in the western North Pacific (WNP), Bering Sea (BS), and eastern North Pacific (ENP) in July from 1972 to 1998.
Ocean age .1.

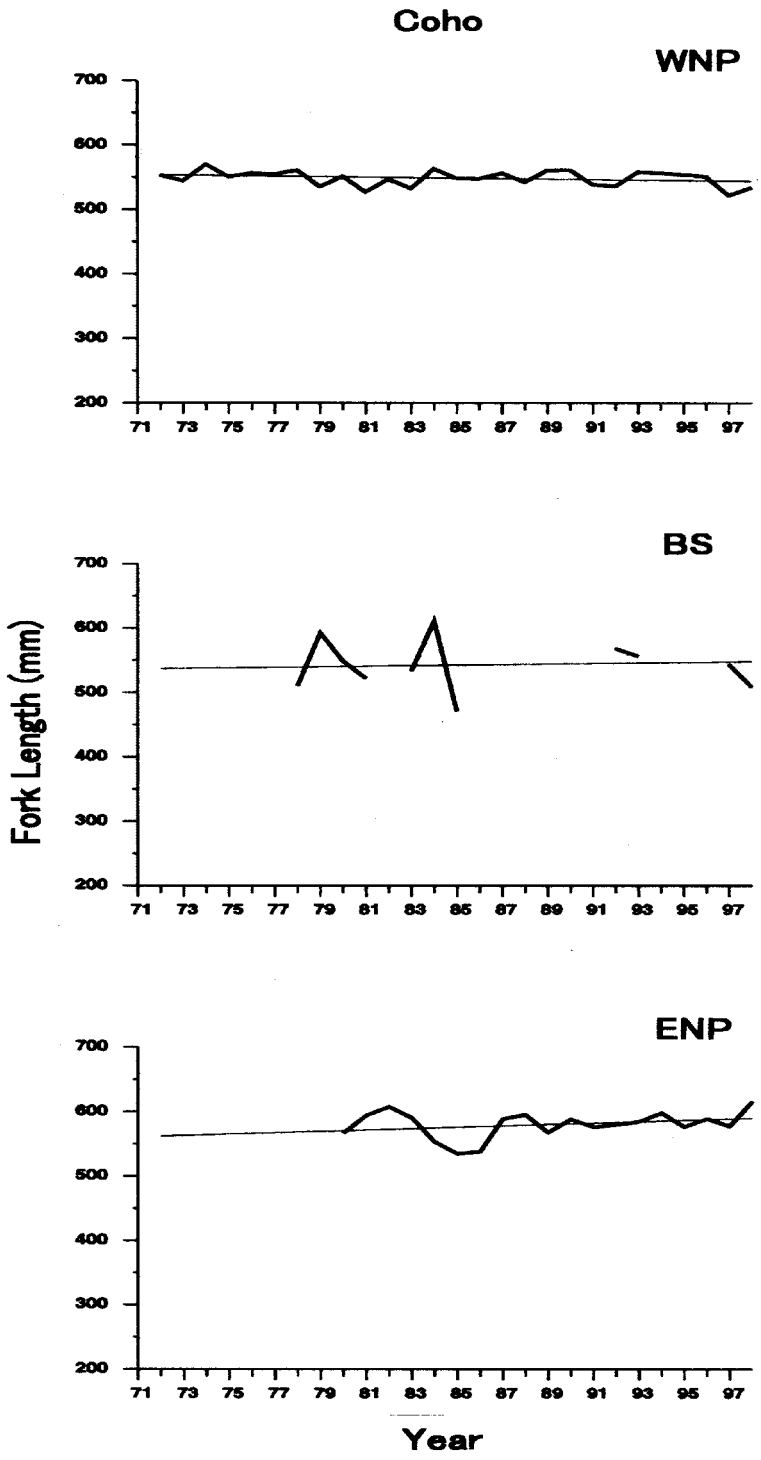

Fig. 9. Changes in fork length of coho salmon in the western North Pacific (WNP), Bering Sea (BS), and eastern North Pacific (ENP) in July from 1972 to 1998. Ocean age .1.

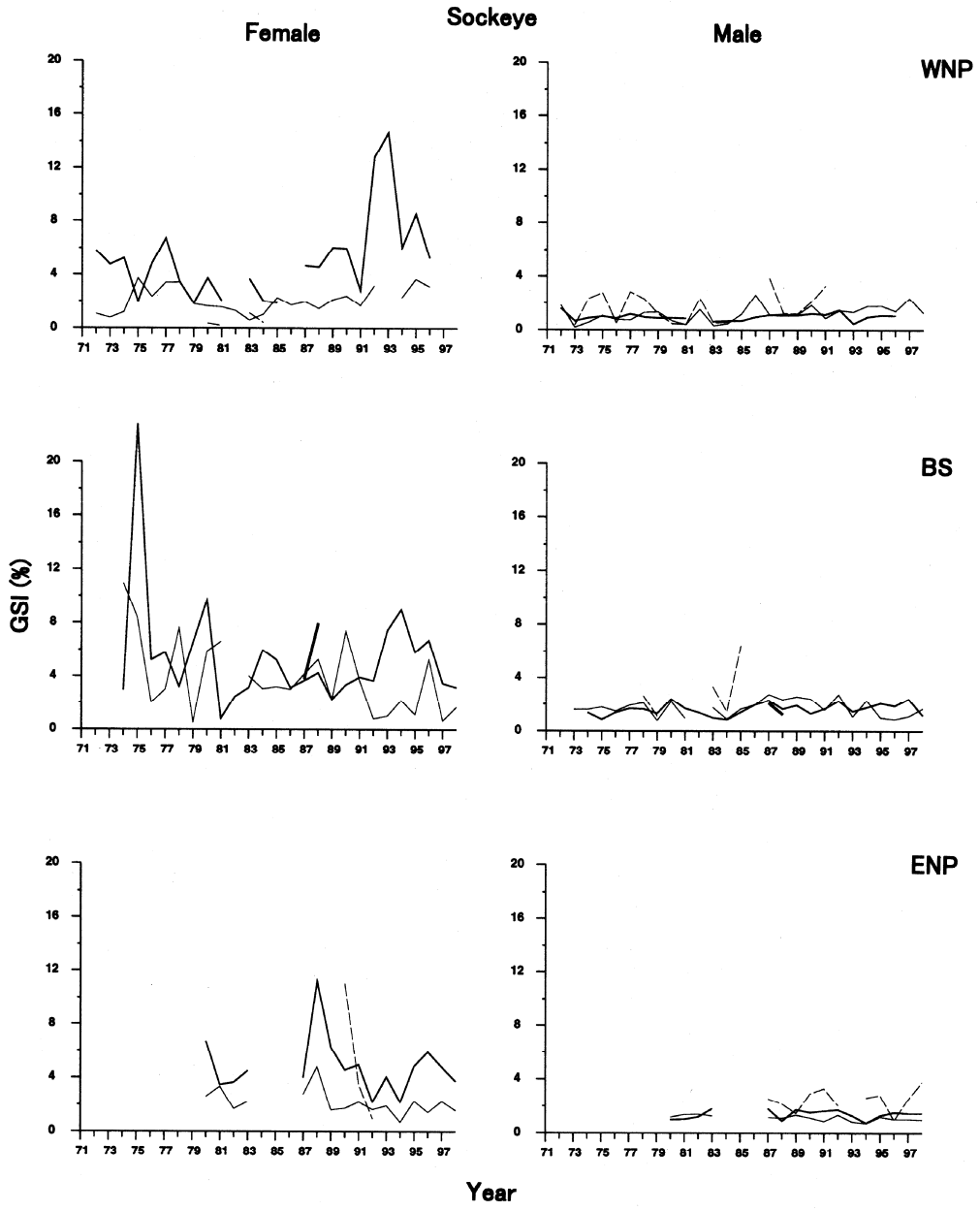

Fig. 10. Changes in gonad somatic index of sockeye salmon in the western North Pacific (WNP), Bering Sea (BS), and eastern North Pacific (ENP) in July from 1972 to 1998.
Ocean age .1 to .3.

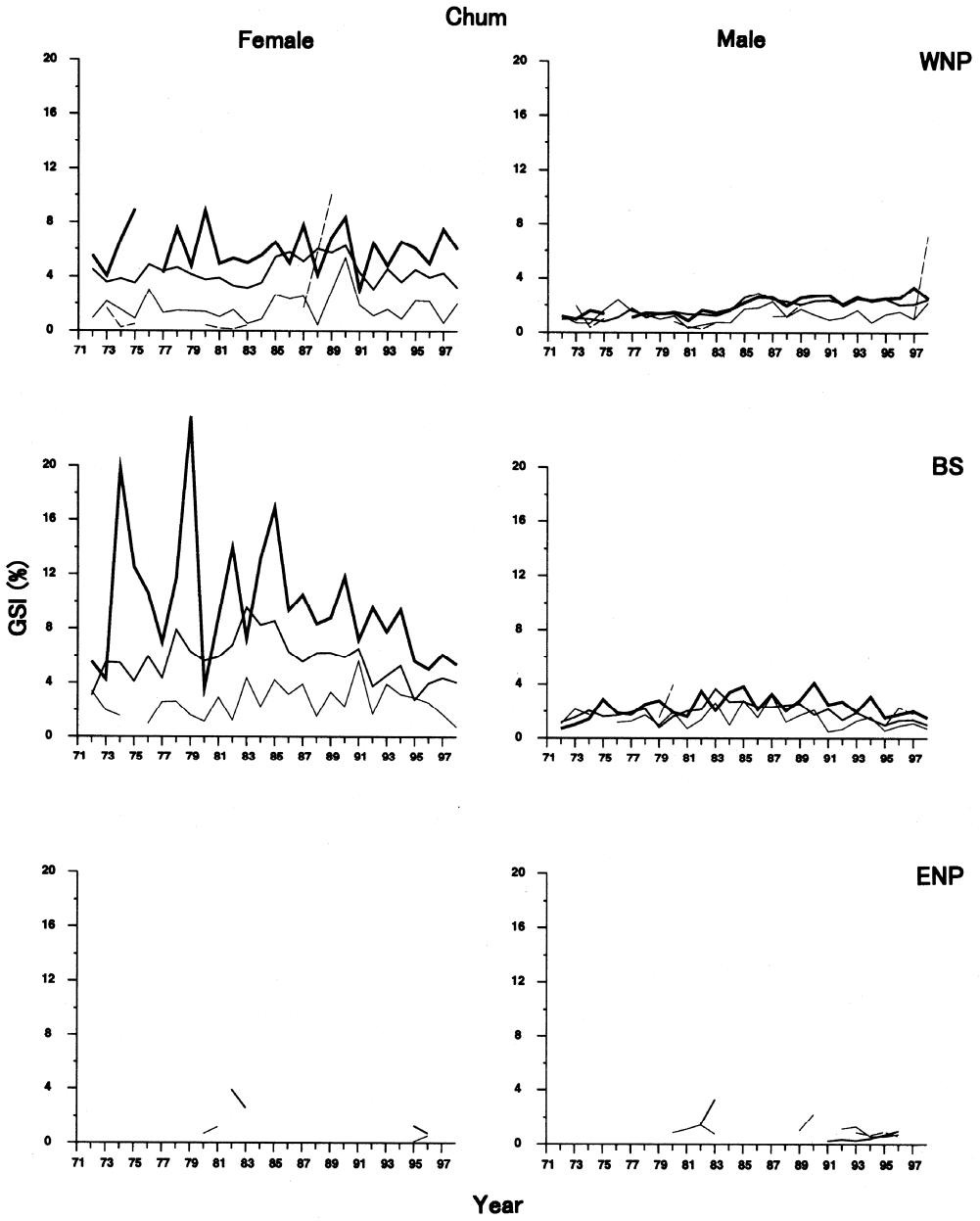

Fig. 11. Changes in gonad somatic index of chum salmon in the western North Pacific (WNP), Bering Sea (BS), and eastern North Pacific (ENP) in July from 1972 to 1998. Ocean age .1 to .4.

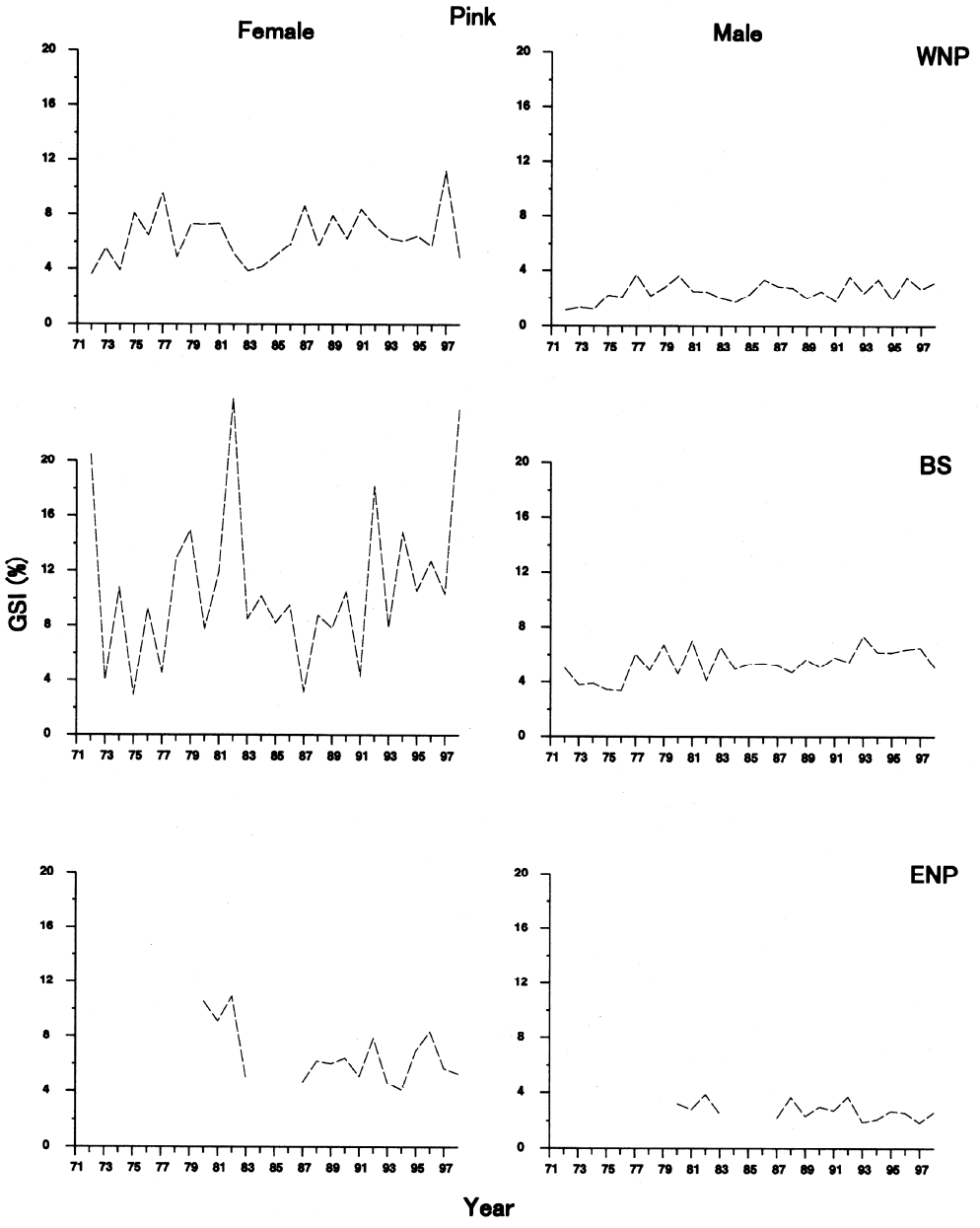

Fig. 12. Changes in gonad somatic index of pink salmon in the western North Pacific (WNP), Bering Sea (BS), and eastern North Pacific (ENP) in July from 1972 to 1998.