NPAFC
Doc. 427
Rev. ____

Abstracts of 1998/99 Japanese Research Results Related to the NPAFC Science Plan

compiled by

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Submitted to the

NORTH PACIFIC ANADROMOUS FISH COMMISSION

by

JAPAN

October 1999

This paper may be cited in the following manner:
Urawa, S. and Y. Ishida. 1999. Abstracts of 1998/99 Japanese research results related to the NPAFC science plan. (NPAFC Doc. 427) 21 p. National Salmon Resources Center, Fisheries Agency of Japan, Toyohira-ku, Sapporo 062-0922, Japan.

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This paper summarized Japanese research results related to the 1998/99 NPAFC Science Plan. Twenty-seven papers were reviewed in abstracts according to the following research subjects. In addition, the bibliography of salmonid fishes published in Japan during 1998 was attached at the back.

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1. Life History of Salmonids
1.1 Spatial Distribution

The long-term mean spatial and temporal distribution of CPUE for pink salmon (*Oncorhynchus gorbuscha*) and chum salmon (*O. keta*) in the North Pacific Ocean. Azumaya, T., Y. Ishida, and Y. Ueno. 1999. Salmon Report Series, 47: 130-136. [Hokkaido National Research Institute of Fisheries, Kushiro, Hokkaido 085-0802, Japan]

The long-term mean spatial and temporal distribution of pink salmon *Oncorhynchus gorbuscha* and chum salmon *O. keta* in offshore waters of the North Pacific Ocean was investigated using the data collected on board Japanese salmon research vessels from 1972 to 1992. Pink salmon were distributed in a wide zonal band between 40°N and 50°N and the area of higher CPUE shifted westward as the season progressed. On the other hand, the CPUE of chum salmon was one order of magnitude lower than that of pink salmon. In spring, chum salmon were more widely distributed than pink salmon, with mature chum salmon distributed near coastal waters and the proportion of immature fish increasing in offshore waters as the season progressed. The distribution of chum salmon differed between odd and even years inversely to the pattern observed for pink salmon. In the Bering Sea, the CPUE of pink salmon was higher in odd years than in even years, and the CPUE of chum salmon was lower in odd years than in even years. Also the chum salmon distribution shifted southeastward in odd years. These results suggest that the interaction between pink and chum salmon changed their distributions in the offshore waters of the North Pacific Ocean.

Distribution, migration and growth in the North Pacific Ocean of sockeye salmon (*Oncorhynchus nerka*) produced from the lacustrine form. Nagasawa, K., and S. Ito. 1999. In Stock Enhancement and Sea Ranching (edited by B. R. Howell, B. Moksness, and T. Svåsand). Fishing News Books, Oxford. pp. 168-181. [National Research Institute of Far Seas Fisheries, Fisheries Agency of Japan, 5-7-1 Orido, Shimizu, Shizuoka 424-8633, Japan]

Over 800 x 10^3 juveniles, produced from eggs from lacustrine sockeye salmon, *Oncorhynchus nerka* (Walbaum), from Lake Shikotsu, central Hokkaido, were released into the Nishibetsu River, eastern Hokkaido, in May 1970 after they had been raised in freshwater for 1 year. Among these fish, 213 were captured in offshore waters of the North Pacific Ocean in spring and summer, 1971-72. These sockeye salmon were identified as the fish from the Nishibetsu River by characteristic scale patterns. Most of the sockeye salmon were caught in the western North Pacific (west of 170°E). Fish of ocean age 1 were separated into immature and maturing fish by their ocean distribution. Immature fish resided in offshore waters but maturing fish moved westward to Hokkaido from spring to summer. Fish of ocean age 2 were maturing and moved westward as did maturing fish of ocean age 1. Fork length increased steadily from spring to summer. These results indicate that the juveniles produced from the eggs of lacustrine sockeye salmon were capable of migrating to offshore waters of the North Pacific and, as adults, returning to the river to which they had been transplanted.

Salmon Tagging experiments and recovery of salmon lacking adipose fin collected by Japanese salmon research vessels in the North Pacific Ocean. Ueno, Y., and Y. Ishida. 1999. Salmon Report Series, 47: 36-42. [Tohoku Regional Fisheries Research Institute, Hachinohe, Aomori 031-0841, Japan]

Two Japanese salmon research vessels conducted 44 longline operations in the North Pacific Ocean and its marginal seas in 1998. A total of 756 salmonids (9 sockeye, 734 chum, 4 pink, and 9 chinook salmon) in the Bering Sea, 28 salmonids (3 sockeye, 7 chum, 13 pink, and 4 coho salmon, and 1 steelhead) in the Gulf of Alaska, and 178 salmonids (15 sockeye, 115 chum, 9 pink, 25 coho, 1 chinook salmon, and 13 steelhead trout) in the central North Pacific Ocean, were tagged and released, respectively. Fish were tagged with two disk tags: one issued by the Fisheries Agency of Japan (FAJ) and a second disk tag issued by the Fisheries Research Institute (FRI).

Both disk tags were placed on one plastic cinch strap and applied to the fish anterior to the dorsal fin. A subset of the disk-tagged fish was released with an externally attached the temperature-recording archival tag including 12 large steelhead and one sockeye released in the central North Pacific Ocean, 3 sockeye, one chum, 4 pink, 3 coho, and one steelhead released in the Gulf of Alaska, and 23 chum salmon released in the central Bering Sea. Another subset of 25 disk-tagged chum salmon was released in the Bering Sea with an internally inserted the temperature, depth, and location recording archival tag. Four Japanese salmon research vessels conducted a survey for salmonids lacking fins, and two sockeye, 3 chum, 6 coho, one chinook salmon, and 68 steelhead trout lacking the adipose fin and/or other fins were recovered. The percentage of steelhead trout lacking adipose fin in 1998 (29.4%=68/231; steelhead trout lacking adipose fin/the total steelhead trout catch) was comparatively low in the recent years (21.9% in 1992; 26.1% in 1993; 30.5% in 1994; 37.1% in 1995; 46.1% in 1996; 44.0% in 1997).

Winter distribution and migration of Pacific salmon. Ueno, Y., Y. Ishida, K. Nagasawa, and T. Watanabe. 1999. Salmon Report Series, 48: 59-79. [Tohoku Regional Fisheries Research Institute, Hachinohe, Aomori 031-0841, Japan]

The purpose of this study is to elucidate the winter distribution and migration of Pacific salmon (*Oncorhynchus* spp.). Oceanographic and biological data collected in the trans-Pacific survey in early-winter (1992), midwinter (1996) and late winter (1998) were analyzed. The seasonal changes of the distribution of sockeye, chum salmon (except for juvenile), and coho strongly suggest that they migrate eastwards from the western or central North Pacific to the eastern North Pacific in the winter. We consider that the stronger eastward water transport or the stormy condition in the upper ocean in the western North Pacific accelerates the eastward migration of these salmons. A large amount of juvenile chum (0.0) and pink (0.0) salmon occurred in the western North Pacific Ocean in the midwinter. SST 8°C and salinity 33.2-33.7 at 10m depth were considered to be indices of the southern boundary of salmon distribution in the western and central North Pacific. These indices suggest that only sub-arctic waters are suitable for wintering salmon. Abundant zooplankton and low temperatures in the sub-arctic waters seem to make juvenile salmon to get a much food supply (zooplankton) and to decrease the metabolic rate. Catch distribution of salmon suggest that northern boundary of salmon distribution were accorded with waters of about 4°C isotherms at sea surface in the western and central North Pacific in late winter. However, a few chinook salmon occurred in waters north of this northern boundary, where the SSTs were ranging from 1°C to 4°C.

Rapid dives and ascents of sockeye salmon *Oncorhynchus nerka* observed by ultrasonic telemetry in the open sea. Ogura, M. 1999. Fish. Sci., 65: 659-660. [National Research Institute of Far Seas Fisheries, Orido, Shimizu, Shizuoka 424-8633, Japan]

Three of the 4 fish tracked showed unusual deep and fast vertical movements; (i) The sockeye (#1) descended in the afternoon of the fourth day of tracking from 6 m to 150 m in 66 5 (2.19 m/s) and then ascended slowly (0.16 m/s) to 5 m. Eight and a half hours after this rapid vertical excursion, the tracking was terminated because the transmitter may become separated from the fish or the fish may die. (ii) The sockeye (#2) dived at the afternoon of the second day of tracking from 4 m to 49 m in 30 5 (1.50 m/s) and then dived to about 80 m at a slower rate (0.15 m/ s). Immediately following this dive, fish ascended at 0.83 m/s to 10 m and then at a slower rate (0.03 m/s) to near surface. (iii) At nighttime, two and a half hours after the previous rapid vertical excursion, the same fish (#2) dived from 31 m to 174 m at 0.43 m/s, and then continued down to 220 m at a slower rate (0.16 m/s). During the subsequent 2 hours, this fish swam between 207 and 244 m. The fish then ascended to 170 m at 0.16 m/s, and ascended to 11 m at 0.63 m/s; between 144 and 70 m ascended at 1.14 m/s. Sixteen hours after this second ascension, the fish (#2) was lost. (iv) The sockeye (#3) dived at the afternoon of the first day of tracking, 8 hours after release, from the surface to 65 m in 105 s (0.62 m/s); between 8 and 52 m the rate of descent was 1.41 m/s. After about one minute at 52 m, the fish ascended slowly (0.15 m/s). The tracking of this fish (#3) was continued two days after this vertical excursion and lost.

1.2 Growth and Maturity

Age determination of salmon (*Oncorhynchus keta*) using scale pattern analysis. Endo, Y., O. Watarai, and M. Igarashi. 1998. J. School Marine Sci. Tech. Tokai Univ., 46: 1-15.

A scale of salmon (*Oncorhynchus keta*) is a small object with a diameter of approximately five millimeters, in which circuli patterns like those of annual ring found in the tree are observed by a microscope examination. In the patterns, two kinds of belting zone of rings are also observed, one of which is referred as "resting zone (or winter zone)" and the other "growth zone (or summer zone)". The number of the resting zone is regarded equal to the age of the fish. The work of scale reading, being carried out, in many fisheries laboratories, is quite a worrisome task for biologists; especially the reading of enormous scale impose a heavy burden of them. For purpose of saving their labors, the authors have designed and developed an instrument system for determining the age of chum salmon using its scale pattern data optically read using a CCD image sensor. In the present paper, the authors propose a new algorithm for extracting the number resting zones for the analysis of fish age. The results of the age determination by the ages measured by the proposed method coincided with those measured by the visual method on approximately 76.5 percent of the fish sampled. It was shown that the proposed system was useful for the purpose of estimating the fish age from the scale pattern information.

GnRH analog stimulates gonadotropin ll gene expression in maturing sockeye salmon. Kitahashi, T., D Alok, H. Ando, M. Kaeriyama, Y. Zohar, H. Ueda, and A. Urano. 1998. Zool. Sci., 15: 761-765. [Graduate School of Science, Hokkaido University, Sapporo, Hokkaido 060-0810, Japan]

Our previous study suggested that, in the pituitaries of pre-spawning chum salmon, salmon gonadotropin - releasing hormone (sGnRH) stimulates expression of genes for gonadotropin (GTH) IIβ but not for Iβ, since the levels of mRNAs encoding sGnRH and GTH II but not I were increased during the final stages of spawning migration. In the present study, a capsule of GnRH analog (GnRHα) was implanted into the dorsal muscle of maturing sockeye salmon to clarify function of GnRH on expression of GTH subunit genes in pre-spawning homing salmonids. The amounts of GTH subunit mRNAs in the individual pituitaries were analyzed by a quantitative dot blot analysis using single - stranded sense DNA as the standard. The levels of GTHα and IIβ mRNAs in the GnRHα - implanted fish were significantly higher than those in the control fish in both the males and females, whereas the levels of GTH Iβ mRNA did not show any significant differences in both sexes. These results indicate that GnRH elevates expression of GTH subunit genes, which encode the components of GTH IIα and IIβ chains, in the pituitary of maturing sockeye salmon, and then accelerates final maturation.

Changes in the levels of gonadotropin subunit mRNAs in the pituitary of pre-spawning chum salmon. Kitahashi, T., H. Ando, M. Ban, H. Ueda, and A. Urano. 1998. Zool. Sci., 15: 753-760. [Graduate School of Science, Hokkaido University, Sapporo, Hokkaido 060-0810, Japan]

We only have little information on expression of gonadotropin (GTH) subunit genes during spawning migration in salmonids. Changes in the levels of mRNAs for GTH subunits (GTHα2, lβ and llβ) were therefore analyzed in the pituitaries of chum salmon (*Oncorhynchus keta*) during the final stages of spawning migration to the Ishikari river. The fish were caught at Atsuta, a fisherman's village facing the Ishikari bay, and at Chitose, a tributary of the Ishikari river, in 1993 and 1994. The former is referred to as seawater (SW) fish, and the latter as freshwater (FW) fish. The levels of GTH subunit mRNAs in the pituitaries were determined by a quantitative dot blot analysis, using single-stranded sense DNA as the standard. The sense DNAs have the same nucleic acid sequences of mRNAs. The level of GTHα 2mRNA in the FW males was higher than that in the SW ones. Similar tendency was seen in the females. No significant changes were observed in the levels of GTH l*b* mRNA in both the males and females. Whereas, the level of GTH llβ mRNA in the FW fish was higher than that in the SW fish regardless of sexes in 1994. Although not statistically significant in the males, similar tendency was seen in the 1993 fish. The present study thus showed that the level of GTH llβ mRNA was increased concomitantly with that of GTHα2 mRNA during the final stages of spawning migration.

Carbohydrate and amino acid metabolism in the liver of masu salmon *Oncorhynchus masou* in the early period of seawater migration. Shikata, T. 1998. Fish. Sci., 64: 487-491. [Ishikawa Prefectural Fisheries Research Center, Ushitsu, Noto, Ishikawa 927-0435, Japan]

About 100,000 individuals of masu salmon *Oncorhynchus masou* were released into the Ukai River in Noto Peninsula. Then the released fish were collected in the river and coastal zone of the peninsula, and the hepatic enzyme activities were determined to investigate the metabolic response in the liver during the migration from river to sea. The activities of amino acid degrading enzymes (alanine aminotransferase and aspartate aminotransferase) and gluconeogenic enzyme (fructose-1, 6-diphosphatase) were significantly higher in the fish caught in the sea than in those caught in the river, whereas no remarkable difference in the lipogenic and glycolytic enzyme activities was found between the fish caught in the river and those caught in the sea. These results suggest that amino acid degradation and gluconeogenesis in the liver of masu salmon were enhanced in the early period of seawater migration.

Acceleration of gonadal maturation in anadromous maturing sockeye salmon by gonadotropin-releasing hormone analog implantation. Fukaya, M., H. Ueda, A. Sato, M. Kaeriyama, H. Ando, Y. Zohar, A. Urano, and K. Yamauchi. 1998. Fish. Sci., 64: 948-951. [Toya Lake Station for Environmental Biology, Faculty of Fisheries, Hokkaido University, Abuta, Hokkaido 049-5723, Japan]

The effects of a three week intramuscular implantation of gonadotropin-releasing hormone analog (GnRHα) on gonadal maturation and changes in serum gonadal steroid hormone levels were examined in anadromous, maturing sockeye salmon *Oncorhynchus nerka* during the pre-spawning season. Spermiation occurred in both GnRHα-implanted and control males, but serum l7α, 20βdihydroxy4-preg-nen-3-one (DHP) levels in the implanted males were higher than in controls. No differences were found in serum testosterone (T) levels between GnRHα-implanted and control males. Serum 1 1-ketotestoster-one (1 1KT) levels in control males increased for three weeks, but those in GnRHα-implanted males did not change. All GnRHα-implanted females ovulated completely for three weeks, while *25%* of control females ovulated partially and the rest of females ovulated 17-24 days after sampling. The number of ovulated eggs of GnRHα-implanted females was greater than that of control females, and percentages of eyed eggs were not different between GnRHα-implanted and control females. Serum levels of DHP increased dramatically in GnRHα-implanted females, but those of T and estradiol-l7β (E_2) was similar to control females. These results confirm that GnRHα accelerates gonadal maturation of both sexes through elevation of serum DHP levels in maturing sockeye salmon.

1.3 Feeding Ecology

Chum salmon feeding habits in relation to growth reduction. Ishida, Y., and N. D. Davis. 1999. Salmon Report Series, 47: 104-110. [Hokkaido National Research Institute of Fisheries, Kushiro, Hokkaido 085-0802, Japan]

Feeding ecology of chum salmon was examined and related to their growth reduction in the third year of ocean life. Analysis of chum salmon stomach contents by age group indicated that age 0.1 fish contained a relatively high proportion of amphipods as compared to the other age groups. However, prey composition was similar among older chum salmon (age 0.2 to 0.5). Captured food weight, an index of the amount of food consumed, of immature age 0.2 chum salmon was the highest, followed by maturing age 0.3, immature age 0.3, and immature age 0.1. Growth reduction of chum salmon in the third year of ocean life may be partly due to a requirement of immature age 0.2 fish chum salmon to consume a large amount of prey.

Effect of feed preparation methods on dietary energy budgets in carp and rainbow trout. Ohta, M., and T. Watanabe. 1998. Fish. Sci., 64: 99-114. [Research Center, Nippon Formula Feed Mfg. Co., Ltd., Oozima, Yaizu, Shizuoka 425-0066, Japan]

This study was conducted to clarify the energy requirements for maintenance of body weight and activity, and for maximum growth in carp and rainbow trout, specifically examining the effect of feed preparation methods on dietary energy budgets and nitrogen balance. Carp (31 g, 17°C), rainbow trout juvenile (31 g, 9 and 16°C), and rainbow trout fingerlings (5.7 g, 16°C) were fed isocontent ordinary dry pellets (DP) produced by a pellet mill and extruded pellets (EP) by a twin-screw extruder. Carp fed EP to satiation showed markedly reduced feeding rate, low percent gain and feed efficiency compared to those fed DP to satiation. In rainbow trout EP tended to be generally lower in the feeding rate and higher in the percent gain and feed efficiency than DP at the satiating levels. This tendency was conspicuous for the growth of fingerling and the feed efficiency at a low temperature. The energy digestibility of EP increased from that of DP in rainbow trout, in relation to the gelatinization of starch. The energy budget in fish fed enough amounts of energy required for maximum growth was determined. The fecal energy loss in DP was relatively large among all the tests, and the digestible and metabolizable energy values of EP were elevated in relation to the fecal energy values. The non-fecal energy losses in rainbow trout were somewhat higher in EP than those in DP. The heat increment of feeding was high in DP and the proportions of productive energy were high in EP in all the experiments.

2. Population Dynamics

2.1 Abundance, Monitoring, and Forecasting

Stock abundance and fish size of Pacific salmon in the North Pacific Ocean, 1998. Ishida, Y., T. Azumaya, Y. Ueno, G. Anma, T. Meguro, H. Yamaguchi, Y. Kajiwara, S. Takagi, Y. Kamei, K. Sakaoka, N. D. Davis, R. V. Walker, and K. W. Myers. 1999. Salmon Report Series, 47: 2-25. [Hokkaido National Research Institute of Fisheries, Kushiro, Hokkaido 085-0802, Japan]

This document summarizes the results of salmon stock assessment research conducted by Japan in 1998. Mean sea surface temperatures, stock abundance and body size of salmonids in 1998 are compared to those from 1991 to 1997. Four Japanese salmon research vessels (*Oshoro maru, Hokusei maru, Hokko maru, and Wakatake maru*) conducted oceanographic observations, 75 gillnet fishing operations (3,332 tan), and 44 longline fishing operations (997 hachi) in the western and eastern North Pacific, and Bering Sea from June to August 1998. Mean sea surface temperatures in 1998 was 11.4°C in the western North Pacific, 7.51°C in the Bering Sea, and 9.97°C in the eastern North Pacific, which was comparable with the previous seven-year means. A total of 18,315 salmonids were caught by fishing operations, including 8,579 chum (47%), 4,918 pink (27%), 2,179 sockeye (12%), 1,849 coho (10%), and 473 chinook (3%) salmon, and 231 steelhead trout (1%) and 86 Dolly Varden (0.5%). Sockeye salmon abundance in 1998 was 42% higher in the western North Pacific, 13% lower in the Being Sea, and 6% higher in the eastern North Pacific than the past seven-year means. Chum salmon abundance was 11%, 31%, and 54% higher in the respective areas. Pink salmon abundance was 45% higher in the western North Pacific, 46% lower in the Bering Sea, and more than two times higher in the eastern North Pacific compared to the past even-year means. Coho salmon abundance in 1998 was 64% and 25% higher than the past means in the western and eastern North Pacific. Chinook salmon in the Bering Sea was very high and about eight times of the past mean. Steelhead trout abundance was 58% and 89% higher in the western and eastern North Pacific compared to the past means. As a whole, stock abundance of Pacific salmon in 1998 was higher than the past mean. Body size of ocean age-1 sockeye in the eastern North Pacific was smaller than those in the past years. Body sizes of ocean age-2 immature chum salmon in the western North Pacific and Bering Sea were smaller than the past means. Also ocean age-3 immature chum salmon in the western North Pacific was smaller than those in the past. Body sizes of pink were smaller in the western North Pacific and Bering Sea compared to the past means. Body size of coho in the western North Pacific was smaller like in 1997, but body size in the eastern North Pacific was larger than the past mean. The reduction in body size of ocean age-2 chum and pink salmon in the western North Pacific and Bering Sea suggest that growth conditions in these areas in 1998 were not so good compared to those in the past years.

Japan-Russia-U.S. cooperative survey on overwintering salmonids in the western and central North Pacific Ocean and Bering Sea aboard the *Kaiyo Maru*, 3 February-2 March, 1998. Ishida, Y., Y. Ueno, A. Shiomoto, T. Watanabe, T. Azumaya, M. V. Koval, and N. D. Davis. 1999. Salmon Report Series, 48: 1-18. [Hokkaido National Fisheries Research Institute, Kushiro, Hokkaido 085-0802, Japan]

A Japan-Russia-U.S. cooperative overwintering salmonid survey was conducted on board the Japanese research vessel *Kaiyo maru* in the western (165°E)and central (180°) North Pacific Ocean and Bering Sea (180°) from 3 February to 2 March 1998, to clarify information on the offshore distribution of Pacific salmon (*Oncorhynchus* spp.) and the relation of oceanographic conditions and salmonid distributions. This was the third overwintering salmonid survey conducted on board the *Kaiyo Maru*. The first two surveys were trans-Pacific cruises (Nov.-Dec. 1992 and Jan. 1996), however, this cruise was the first wintertime salmon research cruise in the central Bering Sea since 1963. Salmon were caught at 14 of 19 trawl stations. A total of 2,383 salmonids were collected. Chum salmon were the most abundant (N=1,436, 60.3%), followed by pink (N=843, 35.4%) sockeye (N=49, 2.1%), chinook (N=31, 1.3%), and coho salmon (N=24, 1.0%). No steelhead was caught. The majority of the catch (66%) occurred at one station in the western North Pacific Ocean, where there were relatively large catchers of chum and pink salmon. Most of the salmon catch in February 1998 was distributed in a narrow band from 42-45°N in the western North Pacific Ocean (at 165°E), where sea surface temperatures were 3.9-5.0°C, and from 43-46°N in the central North Pacific Ocean (at 180°), where sea surface temperatures were 5.2-6.7°C. Chinook salmon was the only species caught in the Bering Sea. The narrow band of salmon distribution in the western and central North Pacific may be limited to the Subarctic Boundary in the south and to the northern extent of the transition domain in the north.

Japan-U.S. cooperative high-seas salmonid research aboard the R/V Wakatake maru from June 9 to July 25, 1998. Ueno, Y., N. D. Davis, M. Sasaki, and I. Tokuhiro. Salmon Report Series, 47: 44-92. [Tohoku Regional Fisheries Research Institute, Hachinohe, Aomori 031-0841, Japan]

An annual Japan-U.S. cooperative high-seas salmonid research cruise, initiated in 1991, was conducted in the central North Pacific Ocean and Bering Sea from June 11 to July 25, 1998, on board the Japanese research vessel Wakatake maru to investigate salmon stock condition. Research cruise activities included collection of data on oceanography, primary production, zooplankton, salmonids, and other organisms. Results of oceanographic data indicated that the average sea surface temperature (SST) in the central North Pacific was 9.1°C (0.4°C cooler in 1998 than in this region in 1997) and the average SST in July in the Bering Sea was 8.2°C (1.1°C cooler than in 1997). A total of 8,635 salmonids (*Oncorhynchus* spp. and *Salvelinus malma*) was caught by longline and gillnet. In the North Pacific Ocean, coho salmon (*O. kisutch*) was the most abundant salmon (57% of the salmonid catch), followed by chum salmon (*O. keta*; 25%), steelhead (*O. mykiss*; 8%), sockeye (*O. nerka*; 5%), pink (*O. gorbuscha*; 3%), and chinook salmon (*O. tshawytscha*; 2%). One masu salmon (*O. masou*) was collected at 46°00’N 180°00’, which may be the eastern-most recorded catch of this species. In the Bering Sea, chum salmon was the most abundant salmon (84% of the salmonid catch), followed by sockeye (9%), chinook (5%), pink (1%), and Dolly Varden (1%, *S. malma*). We examined the stomach contents from 893 salmonids including 123 sockeye, 421 chum, 43 pink, 95 coho, 105 chinook salmon, 20 steelhead, and 86 Dolly Varden. Tissue samples were collected from 800 chum salmon for stock identification by gel electrophoretic analysis. A total of 884 salmonids was double-tagged with disk tags and released to the sea. Most of these fish were chum salmon (809), however, sockeye, coho, steelhead, chinook, and pink salmon were also tagged and released. A subset of the disk-tagged fish was released with an externally attached temperature-recording archival tag including 12 large steelhead released in the central North Pacific Ocean and 23 chum salmon released in the central Bering Sea. Another subset of 25 disk-tagged chum salmon was released in the Bering Sea with an internally inserted temperature, depth, and location recording archival tag. A dummy tag (similar in size and shape to the archival tag, but without the electronic sensors) was surgically inserted into seven coho, six sockeye, and four chum salmon. These fish were reared in a tank on deck and observed to evaluate the influence of the surgical operation on their survival. All salmon died within 16 days.

Japan-Russia-U.S. cooperative survey on overwintering salmonids in the western and central North Pacific Ocean and Bering Sea aboard the Kaiyo maru, 3 February-2 March, 1998. Ishida, Y., Y. Ueno, A. Shiomoto, T. Watanabe, T. Azumaya, M. V. Koval, and N. D. Davis. 1999. Salmon Report Series, 47: 112-128.

A Japan-Russia-U.S. cooperative overwintering salmonid survey was conducted on board the Japanese research vessel Kaiyo maru in the western (165°E) and central (180°) North Pacific Ocean and Bering Sea (180°) from 3 February to 2 March 1998, to clarify information on the offshore distribution of Pacific salmon (*Oncorhynchus* spp.) and the relation of oceanographic conditions and salmonid distributions. This was the third overwintering salmonid survey conducted on board the Kaiyo maru. The first two surveys were trans-Pacific cruises (Nov.-Dec. 1992 and Jan. 1996), however, this cruise was the first wintertime salmon research cruise in the central Bering Sea since 1963. Salmon were caught at 14 of 19 trawl stations. A total of 2,383 salmonids were collected. Chum salmon were the most abundant (N=1,436, 60.3%), followed by pink (N=843, 35.4%), sockeye (N=49, 2.1%), chinook (N=31, 1.3%), and coho salmon (N=24, 1.0%). No steelhead was caught. The majority of the catch (66%) occurred at one station in the western North Pacific Ocean, where there were relatively large catches of chum and pink salmon. Most of the salmon catch in February 1998 was distributed in a narrow band from 42°-45°N in the western North Pacific Ocean (at 165°E), where sea surface temperatures were 3.9°-5.0°C, and from 43°-46°N in the central North Pacific Ocean (at 180°), where sea surface temperatures were 5.2-6.7°C. Chinook salmon was the only species caught in the Bering Sea. The narrow band of salmon distribution in the western and central North Pacific may be limited to the Subarctic Boundary in the south and to the northern extent of the transition domain in the north.

2.2 Mortality

2.3 Stock Interaction

Density-dependent effects on body weight of the pink salmon in the Japan Sea. Hiyama, Y., S. Hasegawa, and F. Kato. 1998. Bull. Japan Sea Natl. Fish. Res. Inst., 48: 17-25. [Japan Sea National Fisheries Research Institute, Suido-cho, Niigata 951-8121, Japan]

Fork length FL, body weight BW, and condition factor $100BW/FL^3$ of the pink salmon *Oncorhynchus gorbuscha* distributed in the Japan Sea are examined in relation to stock size. Body weight and condition factor of the specimens caught by research vessels from April to May

1978-1991 are inversely correlated ($P < 0.01$) with stock size (number of individuals) calculated using Virtual Population Analysis by 10 days, while there are no significant correlations in March. Occurrence of specimens with empty stomachs if also correlated with the stock size with the exception of 1989. Spawning success, which is measured as a logarithm of recruitment / spawning biomass ratio, is correlated ($P < 0.01$) with the spawning biomass (negative) and condition factor (positive). From this, we suggest that there are density-dependent effects on the body size and spawning success of pink salmon distributed in the Japan Sea.

Trophic relations of juvenile salmon (genus *Oncorhynchus*) in the Okhotsk Sea and Pacific waters off the Kuril Islands. Tmamura, R., K. Shimazaki, and Y. Ishida. 1999. Salmon Report Series, 47: 138-168.

In order to clarify trophic relations and feeding habits juvenile salmon and other major pelagic fishes, we examined the stomach contents of juvenile pink salmon (*Oncorhynchus gorbuscha*), chum salmon (*O. keta*), masu salmon (*O. Masou*), sockeye salmon (*O. nerka*), chinook salmon (*O. tshawytscha*), coho salmon (*O. kisutch*), Atka mackerel (*Pleurogrammus monopterygius*), arabesque greenling (*P. azonus*) collected in the Okhotsk Sea and Pacific waters off the Kuril Islands during autumn of 1993. The major preny of pink, chum, and sockeye salmon were planktonic Amphipoda, *Themisto* sp. and *Primno* sp. Chum and pink also fed on a variety of inverbrates such as Gastropoda, Copepoda, Euphausiacea, and *Saggita* spp. Masu, Chinook, and coho salmon mainly fed on Cephalopoda and fishes. Prey species (diet niche) overlap was highest between pink and chum salmon, which were the most abundant species in this study. Prey species composition in their stomach contents is considered to reflect planktonic species composition in the environment. Inter-specific competition was lesser importance in the diets of pink and chum salmon.

2.4 Stock Identification

Stock identification of chum salmon, *Oncorhynchus keta*, based on scale character analysis. Niita, A., and Y. Ueno. 1999. Salmon Report Series, 47: 94-101.

Scale characters of chum salmon collected in Japanese and Russian local stocks (river and coastal areas) were compared to establish a stock identification technique and baseline data on scale characters. Scale samples were collected at seven sites in Japan in 1994 and 16 sites in Russia in 1993 and 1994. Five items of scale characters were measured using the scale character analysis system. The analysis showed that the widths and circuli counts in the first year zone of Japanese local stocks were larger than those of Russian local stocks and that them in the second year zone of Japanese local stocks were fewer than those of Russian local stocks. The above observation suggests that there was a considerable difference in scale character between Japanese and Russian local stocks. However, the serious difference in scale characters between age 3 and 4 was also observed. To examine the relation among local stocks by age, we conducted a cluster analysis for the scale characters by age. The cluster analysis for age 3 fish shows no good geographical contiguous among local stocks in each cluster. In contrast, the cluster analysis for the age 4 fish shows good geographical affinity among local stocks in each cluster. These results demonstrated that scale characters used in this study were effective for stock identification of age 4 (mature) fish and not sufficient for of age 3 (mature) fish. This suggests that other new characters suitable to identify origins of age 3 fish are needed.

The geographical origin of chum salmon (*Oncorhynchus keta*) caught in the western and central North Pacific Ocean in the winter of 1998. Urawa, S., and Y. Ueno. 1999. Salmon Report Series, 48: 51-58. [Research Division, National Salmon Resources Center, 2-2 Nakanoshima, Toyohira-ku, Sapporo062-0922, Japan]

The geographical origin of chum salmon (*Oncorhynchus keta*) caught in the western and central North Pacific Ocean in February 1998 was estimated by genetic stock identification (GSI) techniques. A genetic baseline of protein allozyme characters (19 loci) covering 77 North Pacific rims stocks was used with GIRLS program (Masuda et al., 1991) for mixed stock analysis. In the western North Pacific Ocean (44-46°N, 165°E), young chum salmon (age 0.1) were predominant, and they consisted of 37% Japanese and 45% Russian stocks. In the central North Pacific Ocean (43-45°N, 179°W-180°), age-0.1 chum salmon were rarely distributed, and their composition was 57% Russian and 33% west Alaskan stocks. Most (84-89%) of age-0.2 and -0.3 chum salmon caught in the western and central North Pacific waters were Russian origin. The previous and present GSI results suggest that Japanese chum salmon pass the first winter in the western North Pacific waters but stay in the eastern waters during the following winters.

3. Salmon Habitat and Ecosystem

3.1 Physical-biological Interaction and Productivity

Size composition of phytoplankton in the western Subarctic Gyre in July 1997. Hashimoto, S., and A. Shiomoto. 1999. Bull. Nat. Res. Inst. Far Seas Fish., 36: 77-81. [National Research Institute of Far Seas Fisheries, Fisheries Agency of Japan, 5-7-1 Orido, Shimizu, Shizuoka 424-8633, Japan]

Size compositions (<2, 2-10 and >10 µm) of phytoplankton biomass (chlorophyll a concentration) were investigated within the euphoric layer (100, 30, 10, and 1% light depths) in the Western Subarctic Gyre in July 1997. Mean concentrations of the total, <2, 2-10 and >10 µm fractions were 1.71, 0.85, 0.38, and 0.48 µg 1^{-1}, respectively. The mean relative compositions of the <2, 2-10 and >10 µm fractions were 50, 22 and 28%, respectively, with the <2 µm fraction generally predominated. Moreover, compared to previous results from the Alaskan Gyre, the total and size-fractionated chlorophyll a concentrations were higher in the Western Subarctic Gyre than in the Alaskan Gyre. The relative composition of the >10 µm fraction in the Western Subarctic Gyre (28%) was approximately twice that of the Alaskan Gyre (13%).

Winter chlorophyll *a* concentrations in the western, central and eastern Subarctic North Pacific and the Bering Sea basin. Hashimoto, S., and A. Shiomoto. 1999. Salmon Report Series, 48: 27-37. [National Research Institute of Far Seas Fisheries, Fisheries Agency of Japan, 5-7-1 Orido, Shimizu, Shizuoka 424-8633, Japan]

Chlorophyll *a* concentrations were measured during winter in the western Subarctic North Pacific (WSP), the central Subarctic North Pacific (CSP) (January 1996 and February 1998), the eastern Subarctic North Pacific (ESP) (January 1996), and the Bering Sea basin (BSB). The chlorophyll a concentrations within the upper mixed layer were found to be near homogenous. The chlorophyll *a* concentration within the upper mixed layer tended to be highest in the WSP (0.3-0.8µ g1^{-1}), intermediate in the CSP (0.3-0.7 µg1^{-1}) and lowest in the ESP (0.3-0.5 µg1^{-1}) and BSB (0.3-0.5 µg1^{-1}).

Is there abundant zooplankton prey for salmonids in the Subarctic North Pacific in winter? Nagasawa, K. 1999. Bull. Nat. Res. Inst. Far Seas Fish., 36: 69-75. [National Research Institute of Far Seas Fisheries, Fisheries Agency of Japan, 5-7-1 Orido, Shimizu, Shizuoka 424-8633, Japan]

Macrozooplankton was sampled using a North Pacific standard plankton net during two trans-Pacific cruises of the R/V *Kaiyo maru* at 27 and 23 stations in a wide area of the northern North Pacific Ocean in November-December 1992 and January 1996, respectively. In all of the western and central North Pacific and Gulf of Alaska, the macrozooplankton biomass in these winter months was much lower than that in summer months. Salmonids (*Oncorhynchus* spp.) were captured in waters with low sea surface temperatures (<8°C), where the macrozooplankton biomass remained quite low as well. The salmonids may have a survival strategy to stay in cold waters in order to reduce their energetic consumption, because macrozooplankton as prey is not abundantly available in winter. The cold-water environment appears to be advantageous to the survival of offshore salmonids overwintering under poor food conditions.

Winter zooplankton biomass in the western and central North Pacific Ocean and Bering Sea: survey aboard the R/V *Kaiyo Maru* in February 1998. Nagasawa, K., Y. Ishida, Y. Ueno, and M. V. Koval. 1999. Salmon Report Series, 48: 39-44. [National Research Institute of Far Seas Fisheries, Fisheries Agency of Japan, 5-7-1 Orido, Shimizu, Shizuoka 424-8633, Japan]
Data are presented on the biomass and composition of zooplankton collected by a vertical tow of a Norpac net from 150 m in depth to the surface at 19 stations in the western (165°E) and central (180°) North Pacific Ocean and Bering Sea (180°) in February 1998.

Latitudinal variations in abundance of phytoplankton, macrozooplankton, salmonids, and other epipelagic fishes in the Northern Pacific Ocean and Bering Sea in summer. Nagasawa, K., A. Shiomoto, K. Tadokoro, and Y. Ishida. 1999. Bull. Nat. Res. Inst. Far Seas Fish., 36: 61-68. [National Research Institute of Far Seas Fisheries, Fisheries Agency of Japan, 5-7-1 Orido, Shimizu, Shizuoka 424-8633, Japan]
Latitudinal changes in abundance of phytoplankton, macrozooplankton, salmonids (*Oncorhynchus* spp.) and other epipelagic fishes were surveyed from mid-June to early July in 1992 and 1993 along a transect at 179°30'W from 38°30'N - 58°30'N. In the Bering Sea (52°00'N-58°30'N) where salmonids were abundant, macrozooplankton biomass was low whereas phytoplankton abundance was high. In the Transition Domain (42°00'/43°00'N-46°00'N) with low salmonid abundance, macrozooplankton biomass was high but phytoplankton stock was at a low level. Salmonid abundance annually varied in the Subarctic North Pacific, and when salmonids were abundant there, macrozooplankton biomass was low but phytoplankton stock was high, and vice versa. These results imply that salmonid predation may have resulted in the low abundance of macrozooplankton, which may have enhanced the phytoplankton stock. In the regions with low salmonid abundance, the proportion of large-sized phytoplankton (>10 µm) was low but that of copepods was high, possibly because reduced predation pressure of salmonids may have enhanced the copepod grazing on large-sized phytoplankton. The catch of pink salmon (*O. gorbuscha*) was high in 1993 and this species seems to play an important role in reducing the macrozooplankton biomass in central North Pacific in summer. Since the macrozooplankton biomass in the Transition Domain is controlled by the feeding of planktivorous fishes (e.g., Pacific saury *Cololabis saira*) migrating from the more southerly subtropical North Pacific (38°30'N-42°00'/43°00'N), these fishes appear to give stronger negative effects, than salmonids, on the abundance of macrozooplankton in the Transition Domain where salmonid abundance is low.

Distribution of chlorophyll-*a* concentration in the Transition Domain and adjacent regions of the central North Pacific in summer. Shiomoto, A., Y. Ishida, K. Nagasawa, K. Tadokoro, M. Takahashi, and K. Monaka. 1999. Plankton Biol. Ecol., 46: 30-36. [National Research Institute of Far Seas Fisheries, Fisheries Agency of Japan, 5-7-1 Orido, Shimizu, Shizuoka 424-8633, Japan]
Chlorophyll-*a* (Chl-*a*) concentrations and phytoplankton productivities, as well as physical and chemical environmental factors, were measured in the Transition Domain (TD) and its adjacent regions to the south and north in the central North Pacific during the summers of 1991 to 1996. The Chl-*a* concentrations in the surface layer in the TD were not intermediate between those in the southern and northern regions. The concentration seems to be rather constant and low in the TD compared to the adjacent regions. In contrast, temperature and nutrient levels were found to be intermediate in the TD compared to regions to the north and south. Chl-*a*-specific phytoplankton productivity (an index of phytoplankton growth rate) of the <2,2-10 and 10-200 µm fractions in the TD did not substantially differ from that in the adjacent regions. Phytoplankton growth rate is therefore unlikely to be responsible for the low Chl-*a* concentration in the TD. The standing stock of copepods tended to be largest in the TD. From these results and the previous information about zooplankton in and around the TD, we suggest that heavy grazing

by zooplankton in the TD reduced the phytoplankton standing stock and, therefore, the concentration of Chl-*a* in the area.

Mid-winter thermohaline structure of the western Subarctic Gyre and the Bering Sea.
Watanabe, T., T. Azumaya, and Y. Ishida. 1999. Salmon Report Series, 48: 20-25. [National Research Institute of Far Seas Fisheries, Fisheries Agency of Japan, 5-7-1 Orido, Shimizu, Shizuoka 424-8633, Japan]

The thermohaline structure of the western Subarctic Gyre was observed in February 1998 by conducting scientific observations on board the R/V Kaiyo-maru. The CTD, XCTD and XBT were used to collect data on the detailed structure of the upper ocean. The thermohaline structures along the 165°E and the 180° meridians are described based on XCTD observations. The Subarctic front was located at 45°N on the 165° meridian and at 46°N on the 180° meridian. The wintertime cold and thick mixed layer was well developed, and the seasonal temperature minimum layer above the pycnocline in the ridge region was nonexistent at the 165°E meridian. On the other hand, the permanent temperature minimum structure existed along the 26.8 isopycnal below the pycnocline at the 180° meridian. The temperature maximum structure below the pycnocline was observed at stations north of the Subarctic front.

4. Appendix

Bibliography of Salmonids published in Japan, 1998

This current salmonid bibliography has covered scientific publications in Japan in 1998. Titles are given in English for all articles. A reprint of article may be available from the author. An author's address is shown in square brackets following the citation. The bibliography is divided into the following sections:

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