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Abstracts of 1997/98 Japanese Research Results Related to the NPAFC Science Plan

compiled by

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1. Life History of Salmonids

1.1 Spatial Distribution

Oceanographic conditions and distribution of pelagic nekton in the northwestern North Pacific Ocean during the summer and fall in 1995 and 1996. Takagi, S., Y. Sakurai, Y. Kamei, T. Miyoi, K. Sakaoka, and N. Shiga. Bull. Fac. Fish. Hokkaido Univ., 48: 13-28. In Japanese with English summary. [Faculty of Fisheries, Hokkaido University, 3-1-1 Minato, Hakodate 041, Japan]

Oceanographic conditions and distribution of pelagic nekton during the summer and fall in 1995 and 1996 in the northwestern North Pacific Ocean were examined. The gillnet survey and hydrographic observations were conducted along 155ºE longitude from 32 to 44ºN latitude. The Kuroshio front located at the northern boundary of the Kuroshio extension current was found near 38ºN in the summer and fall. In the summer, warm water from the Kuroshio was found in the subarctic domain. The warm water was associated with an increase in Chl-*a* and zooplankton. In the fall, intermediate cold water occurred in the subarctic domain, and concentrations of nutrients and Chl-*a* were high in fine structure. The distribution of pelagic nekton differed in the summer and fall. In the summer, the dominant species north side of the front were pink salmon and chum salmon. The dominant species around the front was flying squid (*Ommastrephes bartramii*). In the fall, the dominant species in subtropical water were flying squid and dolphin (*Coryphaena hippurus*). The distribution of flying squid was affected by the Kuroshio front. In the summer, the front corresponded to the boundary between LL-size group (north side) and the small-size group (south side). In the fall, the front corresponded to the boundary between immature (north side) and mature (south side) squid.

Life history strategy and migration pattern of juvenile sockeye (*Oncorhynchus nerka*) and chum salmon (*O. keta*) in Japan: a review. Kaeriyama, M., and H. Ueda. 1998. N. Pac. Anadr. Fish Comm. Bull. No. 1: 163-171. [National Salmon Resources Center, Fisheries Agency of Japan, 2-2 Nakanoshima, Toyohira-ku, Sapporo 062, Japan]

Life histories of sockeye (*Oncorhynchus nerka*) and chum salmon (*O. keta*) show a conditional strategy, which has two tactics of residence and migration. They remain in lakes and rivers if they can obtain sufficient resources such as food and habitat, or migrate seaward when they do not have enough resources to satisfy their energy metabolism. Their migration pattern, controlled by effects of "prior residence" and "precedent migration", may be influenced by trade off between the profitability of resource acquisition and risks such as osmoregulation, energetic demands of swimming, exposure to predators, and mobilization to non-adaptable habitat by water current. The life history strategy and migration pattern of the genus *Oncorhynchus* reflect an evolution of anadromous fish by which they have acquired anadromy for obtaining food resources in the sea and homing ability for reproduction in freshwater.

1.2 Growth and Maturity

Scale and otolith patterns prove growth history of Pacific salmon. Fukuwaka, M. 1998. N. Pac. Anadr. Fish Comm. Bull. No. 1: 190-198. [Research Division, National Salmon Resources Center, Fisheries Agency of Japan, 2-2 Nakanoshima, Toyohira-ku, Sapporo 062, Japan]

Scale and otolith patterns are frequently used for age determination, growth estimation, and stock identification of Pacific salmon. However, little information is available about their formation mechanism such as circulus, check in the scale, and growth increment in the otolith. I clarified the formation mechanisms of scale and otolith patterns by rearing experiments using juvenile sockeye and chum salmon. Circulus spacing was positively correlated with somatic growth in juvenile chum salmon. A check was formed soon after release from a hatchery in juvenile chum salmon and at the time of tagging in juvenile sockeye salmon. Growth increments were produced in otolith on a daily basis. An allometric equation fitted for the relationship between fish length and otolith length. These results indicate that growth history of individual fish can be back-calculated from scale and otolith patterns. Circulus spacing is also useful as an indicator of somatic growth. Scale and otolith patterns are influenced by somatic growth rate and by environmental conditions. From this, scale and otolith patterns is useful for the estimation of fish growth through the life history.

Seasonal growth patterns of Pacific salmon (*Oncorhynchus* spp.) in offshore waters of the North Pacific Ocean. Ishida, Y., S. Ito, Y. Ueno, and J. Sakai. 1998. N. Pac. Anadr. Fish Comm. Bull. No. 1: 66-80. [National Research Institute of Far Seas Fisheries, Fisheries Agency of Japan, 5-7-1 Orido, Shimizu, Shizuoka 424, Japan]

Seasonal growth patterns of Pacific salmon (*Oncorhynchus* spp.) in the North Pacific Ocean were explored using biological data collections from the Japanese salmon research programs. Seasonal change in fork length and body weight was similar between sockeye and chum salmon, and between pink and coho salmon. Seasonal change in condition factors was very similar among the five species, that is, condition factors increased in spring, peaked in summer, decreased in fall, and were lowest in winter. Average growth rate in weight during maturing stage was significantly higher than that in immature stage for sockeye, pink, and coho salmon. For chum salmon, there was no significant difference in growth rate between immature and maturing fish, but the growth rate of immature fish was higher than those of other species, especially at age 0.2. Growth rates during life stages when density-dependent growth may occur are higher than those in other life stages. We can hypothesize that higher growth rates require greater demands for food intake, which may lead to density-dependent growth during these rapid-growth seasons if prey resources are limited.

Biochemical approach to assessing growth characteristics in salmonids. Azuma, T., T. Yada, Y. Ueno, and M. Iwata. 1998. N. Pac. Anadr. Fish Comm. Bull. No. 1: 103-111. [Nikko Branch, National Research Institute of Aquaculture, Chugushi, Nikko, Tochigi 321-16, Japan]

Growth characteristics were examined for pink, *Oncorhynchus gorbuscha*, chum, *O. keta*, and sockeye salmon, *O. nerka*, caught in the Okhotsk Sea, North Pacific, and the Bering Sea from biochemical aspects. Adult pink, chum, and sockeye salmon had higher condition factor, protein content, and RNA:DNA and protein:DNA ratios than the juveniles. In adult fishes, while both RNA:DNA and protein:DNA ratios increased with condition factor commonly in the three species, positive correlations of both RNA:DNA and protein:DNA with fork length were seen only in chum salmon. In contrast with adults, juvenile chum salmon exhibited negative correlations of both RNA:DNA and RNA:protein ratios with fork length, and the RNA:DNA ratio decreases with triacylglycerol content. These correlations suggest that juvenile chum salmon build up lipid reserves at the expense of protein synthesis just prior to the onset of winter. However, in juvenile pink salmon alternative strategy was shown in which continued rapid growth is favored. These results suggest that Pacific salmon adopt species-specific strategies for allocating resources for somatic growth, and hence exhibit varying growth characteristics as measured by biochemical parameters that depend on species and life history stage during their years at sea.

Correlations between homing, migration, and reproduction of chum salmon. Ueda, H. 1998. N. Pac. Anadr. Fish Comm. Bull. No. 1: 112-117. [Toya Lake Station for Environmental Biology, Faculty of Fisheries, Hokkaido University, 122 Tsukiura, Abuta 049-57, Japan]

The onset of gonadal maturation which is regulated by the endocrinological functions is considered to play leading roles in making salmon migrate a long distance from the ocean to their natal streams for spawning. Both cytological profiles of salmon gonadotropin-releasing hormone (sGnRH) neurons and serum gonadal steroid hormone profiles are investigated in chum salmon (*Oncorhynchus keta*) during the homing migration. Cytophysiological differences were observed between sGnRH neurons in the olfactory nerve and those in the preoptic area before and after upstream migration; the former could possibly be involved in the olfactory functions, and the latter would appear to be involved in gonadal maturation. Changes in serum steroid hormone levels were measured during the homing migration from the North Pacific Ocean to the spawning grounds, and the results revealed good correlations between estradil-17ß and vitellogenesis, 11-ketotestosterone and spermatogenesis, and 17a, 20ß-dihydroxy-4-pregnen-3-one and final gonadal maturation in both sexes, but the roles of testosterone in gonadal development in both sexes were still obscure. These findings are discussed in relation to homing migration and gonadal maturation of chum salmon.

1.3 Feeding Ecology

Variation in prey size selectivity of fingerling chum salmon (*Oncorhynchus keta*) in sea life: effects of stomach fullness and prey abundance. Suzuki, T., and M. Fukuwaka. 1998. N. Pac. Anadr. Fish Comm. Bull. No. 1: 138-145. [National Salmon Resources Center, Fisheries Agency of Japan, 2-2 Nakanoshima, Toyohira-ku, Sapporo 062-0922, Japan]

Prey size selection by fingerling chum salmon (*Oncorhynchus keta*) was studied with respect to variations in the stomach fullness of fish and their estimated prey abundance in the coastal waters of the Japan Sea off northern Honshu, Japan. Fingerlings mainly fed on zooplankton, and their diets consisted of two size groups of major prey taxa. Fingerlings showed two behavioral patterns: selective foraging for the larger prey and non-selective foraging. The effects of prey abundance on the selectivity of fish were different between the size groups. Fingerlings intensified their foraging selectivity with a increase in the abundance of larger prey. On the contrary, the abundance of smaller prey did not influence the prey size selectivity. The stomach fullness of fish was also positively correlated with the prey size selectivity. Since the abundance of larger prey and the stomach fullness of fish varied independently of each other, both are considered to be important factors affecting the prey size selection and diet composition of fingerling chum salmon in the sea.

2. Population Dynamics

2.1 Abundance, Monitoring, and Forecasting

Historical trends of salmon fisheries and stock conditions in Japan. Hiroi, O. 1998. N. Pac. Anadr. Fish Comm. Bull. No. 1: 23-27. [Research Division, National Salmon Resources Center, Fisheries Agency of Japan, 2-2 Nakanoshima, Toyohira-ku, Sapporo 062, Japan]

Artificial salmon hatchery operation in Japan can be described from various aspects such as salmon resources, resources management, economic effects, and future prospects. Almost all the salmon resources in Japan have been supported by artificial propagation. Recent annual total salmon catch increased to about 300 thousand tons, in which the coastal catch accounted for over 80 percent. With regard to the species composition of commercial catch, the chum catch is the largest, about 230 thousand tons (about 80 %). Resource management coupled with active propagation made the set net fishery for chum and pink salmon stable. Economic returns from harvesting (about 50-80 billion yen) in the coastal fishery vis-a-vis expenses (about 10-14 billion yen) for artificial propagation of salmon is about 5-8 times.

Dynamics of chum salmon, *Oncorhynchus keta*, populations released from Hokkaido, Japan. Kaeriyama, M. 1998. N. Pac. Anadr. Fish Comm. Bull. No. 1: 90-102. [Research Division, National Salmon Resources Center, Fisheries Agency of Japan, 2-2 Nakanoshima, Toyohira-ku, Sapporo 062, Japan]

Body size of Hokkaido chum salmon (*Oncorhynchus keta*) at maturity showed a significant decreasing trend from the late 1970s to the early 1980s and has remained relatively constant since the late 1980s. A significant negative relationship between population abundance and fork length was observed. In Hokkaido chum salmon population, average age at maturity in cohorts increased from 3.7 years in the 1972 cohort to over 4 years in cohorts after 1980. A significant positive relationship between population abundance and average age at maturity of cohorts was observed in the Hokkaido chum salmon population. Growth analysis back-calculated from scales showed that a growth reduction occurred after the second year, especially in the third year of oceanic life of Hokkaido chum salmon. The synchronous decreasing body size and increasing age at maturity of Hokkaido chum salmon occurred in face of rising marine survival rates and ocean conditions favorable for growth. This suggested that reduced growth and increasing age at maturity was due to density dependent intraspecific competition and high abundance of chum salmon on the North Pacific Ocean.

Salmon abundance in offshore waters of the North Pacific Ocean and its relationship to coastal salmon returns. Ishida, Y., and S. Ito. 1998. N. Pac. Anadr. Fish Comm. Bull. No. 1: 334-339. [National Research Institute of Far Seas Fisheries, Fisheries Agency of Japan, 5-7-1 Orido, Shimizu, Shizuoka 424, Japan]

Catch-per-unit-effort (CPUE: fish/tan caught by commercial-type gillnet with mesh sizes from 112 to 130 mm) was calculated using the data collected on board Japanese salmon research vessels in offshore waters of the North Pacific Ocean from 1972 to 1995. These data were stratified by month, 2 degree latitude by 5 degree longitude areas (2x5 areas), species, and maturity, and related to the returns of Japanese chum salmon and Bristol Bay sockeye salmon. Significant correlations and high average CPUEs (sockeye>0.1 and chum>0.3 fish/tan) were found in several areas. There were significant correlations between the abundance of immature chum salmon occurring in areas south of the Aleutian Islands in June (r=0.55* to 0.79**) and the central Bering Sea in July (r=0.51* to 0.63*) and the return of Japanese chum salmon the following year. There were also significant correlations between CPUE of maturing chum salmon in areas south of the Aleutian Islands in June (r=0.57* to 0.85**) and central Bering Sea in June (r=0.68* to 0.79**) and July (r=0.46* to 0.74**) and the current year return of Japanese chum salmon. The abundance of immature fish in areas south of the Aleutian Islands (r=0.47* to 0.65**) and central Bering Sea (r=0.48* to 0.64*) in July was significantly correlated with the returns of Bristol Bay sockeye salmon the following year. There were also significant correlations between the abundance of maturing sockeye in areas south of the Aleutian Islands in June (r=0.65** to 0.86**) and July (r=0.69**) and the current year return of Bristol Bay sockeye salmon. These correlations suggest that abundance of salmon in offshore areas based on CPUE of commercial-type gillnet operations could be used to develop pre-season forecasts of Japanese chum salmon and Bristol Bay sockeye returns.

2.2 Mortality

Predation by salmon sharks (*Lamna ditropis*) on Pacific salmon (*Oncorhynchus* spp.) in the North Pacific Ocean. Nagasawa, K. 1998. N. Pac. Anadr. Fish Comm. Bull. No. 1: 419-433. [National Research Institute of Far Seas Fisheries, Fisheries Agency of Japan, 5-7-1 Orido, Shimizu, Shizuoka 424, Japan]

This paper reviews the biology of salmon sharks (*Lamna ditropis*) and evaluates their current status as predators of Pacific salmon (*Oncorhynchus* spp.) in the North Pacific Ocean. Salmon sharks are widely distributed in subarctic and northern temperate waters. They segregate in distribution by size and sex and conduct seasonal migrations. Larger (older) salmon sharks go to more northern waters. In the western North Pacific, salmon sharks migrate from Japanese waters to the Okhotsk Sea and the western Bering Sea. They copulate in autumn and females bear young in spring. Salmon sharks are long-lived (over 20 years). They are opportunistic feeders but occupy the highest trophic level in the food web of subarctic waters. Salmonids are the major prey item in subarctic waters. Although the importance of each species of Pacific salmon eaten varies among regions, sockeye salmon (*O. nerka*) are most frequently fed on, followed by chum (*O. keta*), pink (*O. gorbuscha*), coho (*O. kisutch*), and chinook (*O. tshawytscha*) salmon. The estimated abundance of salmon sharks was at least about 2 million fish for 1989. Of these fish, age? 5 salmon sharks ($595 x 10^3$ fish) occurring in subarctic waters appear to have consumed 73-146x10^6 salmonids (113-226x10^3 metric tons) from spring to autumn in 1989, which corresponded to 12.6-25.2% of the total annual run of Pacific salmon for that year. I therefore suggest that the predation by salmon sharks highly causes the ocean mortality of Pacific salmon.

Fish and seabird predation on Juvenile chum salmon (*Oncorhynchus keta*) in Japanese coastal waters, and an evaluation of the impact. Nagasawa, K. 1998. N. Pac. Anadr. Fish Comm. Bull. No. 1: 480-495. [National Research Institute of Far Seas Fisheries, Fisheries Agency of Japan, 5-7-1 Orido, Shimizu, Shizuoka 424, Japan]

This paper examines the available literature on the fauna and diets of fishes and seabirds in coastal waters of northern Japan from spring to summer, and discusses the impact of fish and seabird predation on chum salmon (*Oncorhynchus keta*) populations in Japan. Although over 90 fish species have been reported to occur with chum salmon juveniles, fishes recorded as predators in river-mouth areas and at sea are the following nine species: Japanese dace (*Tribolodon hakonensis*), Far Eastern dace (*T. brandti*), white-spotted charr (*Salvelinus leucomaenis*), Japanese halibut (*Paralichthys olivacaeus*), Japanese sea perch (*Lateolabrax japonicus*), spiny dogfish (*Squalus acanthias*), arabesque greenling (*Pleurogrammus azonus*), pink salmon (*O. gorbuscha*) and masu salmon (*O. masou*). Fish predation may cause substantial loss of chum salmon juveniles in localities where these predatory fishes, especially Japanese dace and arabesque greenling, are abundant. However, there is no evidence that fish predation has much impact on the number of returning adult chum salmon in Japan. The release of large hatchery-reared juveniles possibly reduces mortality due to fish predation. Rhinoceros auklets (*Cerorhinca monocerata*) and black-tailed gulls (*Larus crassirostris*) have been recorded as predators of juvenile chum salmon. These seabirds abundantly breed in northern Japan, and the impact of their predation on Japanese chum salmon populations may be significant.

2.3 Stock Interaction

Interaction between chum salmon and fat greenling juveniles in the coastal Sea of Japan off northern Hokkaido. Kawamura, H., M. Miyamoto. M. Nagata, and K. Hirano. 1998. N. Pac. Anadr. Fish Comm. Bull. No. 1: 412-418. [Mashike Branch of Hokkaido Fish Hatchery, Yamanokami 1256, Shokanzawamura, Mashikecho, Mashikegun, Hokkaido, Japan]

The authors examined potential interactions between chum salmon (*Oncorhynchus keta*) and fat greenling (*Hexagrammos otakii*) juveniles in terms of their distribution, abundance, growth and food habit in the Sea of Japan along the Mashike coast in northern Hokkaido. We captured the juveniles by a Sayori tow net from mid-April to mid-June in 1995. To compare the distribution patterns of both species, we calculated the point correlation coefficient (PCC, Dagneli's F) and Morisita's C_d . We used Kimoto's C, as a similarity index of a stomach content composition between the two species, and SCI (Stomach Content Index, %). Although chum salmon juveniles were collected from mid-April to mid-June, fat greenling continued to inhabit till early May. Both species showed the highest abundance in early May and their distributions were restricted to inshore waters except for mid-April. There was a significant correlation of PCC in mid-April

(PCC=0.75, ? ^{2}=6.857, p<0.01), however, Morisita's C_d remained at low levels (0.2-0.28) during the same period. Although there was significant difference in mean fork length between the two species in this period (t-test, P<0.05), frequency distributions of fork length were very similar. The mean values of SCI in mid-April ranged from 0.6% to 1.1% for chum salmon and from 0.8% to 1.8% for fat greenling among the sampling sites. The same food organisms, *Tortanus discaudatus* and *Themisto japonica*, were found in the stomachs of both species. Kimoto's C showed high values ranging from 0.34 to 0.58 in mid-April. It is suggested that there is potential competition between chum and fat greenling juveniles in terms of the food and habitat requirements during the early ocean life of chum salmon juveniles.

2.4 Stock Identification

Stock identification of chinook salmon (*Oncorhynchus tshawytscha*) in the North Pacific Ocean and Bering Sea by parasite tags. Urawa, S., K. Nagasawa, L. Margolis, and A. Moles. 1998. N. Pac. Anadr. Fish Comm. Bull. No. 1: 199-204. [Research Division, National Salmon Resources Center, Fisheries Agency of Japan, 2-2 Nakanoshima, Toyohira-ku, Sapporo 062, Japan]

The continental origins of chinook salmon (*Oncorhynchus tshawytscha*) in the North Pacific Ocean and Bering Sea were estimated by using two freshwater parasites (*Myxobolus arcticus* and *M. kisutchi*) as biological tags. The parasite survey of adult chinook salmon from major spawning rivers in North America and Kamchatka indicated that *M. arcticus* was commonly found in Asian chinook stocks (prevalence=57-94%), while rarely among most North American stocks except for those from Vancouver Island, B. C. The unweighted overall sample prevalence of *M. arcticus* was 67.7% and 2.3% in Asian and North American stocks, respectively. *Myxobolus kisutchi* was found only in chinook salmon from the Columbia River (prevalence=8-11% and 43-51% in fall and spring adult stocks, respectively) and its vicinities. The prevalence of *M. arcticus* in high-seas samples of chinook salmon showed a distinct longitudinal cline in the North Pacific Ocean: the overall prevalence was 92% west of 160ºE, 81% between 160ºE and 170ºE, 58% between 170ºE and 180º, and 38% between 150ºW and 160ºW, whereas it was only 0-3% in the central Bering Sea. These results suggest that Asian chinook salmon are widely distributed in the North Pacific Ocean, occurring possibly as far east as 150ºW, and are probably predominant in the waters west of 180º. The extreme low prevalence of *M. arcticus* in central Bering Sea chinook salmon suggests that up to 98% of chinook salmon caught in this area are of North American origin. One chinook salmon infected with *M. kisutchi* was found in the Gulf of Alaska, suggesting the presence of Columbia River chinook salmon in this area.

Identification of long and short-term reared masu salmon with quantified scale characteristics. Ohkuma, K. 1998. N. Pac. Anadr. Fish Comm. Bull. No. 1: 319-326.

Masu salmon (*Oncorhynchus masou)* are important to coastal commercial fisheries in northern Japan. Enhancement programs include a combination of release of fry in the spring (short-term rearing: ST) and release as juveniles in the fall, or as smolts the following spring (both long-term rearing: LT). In recent years, the number of LT fish released has increased and it has been practically and financially difficult to mark all of the releases. A simple and accurate method is needed to identify LT and ST fish in the overall numbers of returning adult masu salmon, to evaluate the success of alternative rearing and release strategies. Accordingly, a modification of the assignment rule, which was developed to identify wild and hatchery steelhead stocks in Lake Michigan, was applied to masu salmon. Scales of 1,129 adult masu salmon, which returned to the Shiribetsu River in 1989, were examined and various numerical scale characteristics (SR, CN, IN5, OUT5, and R5) were compared between the LT and ST fish groups. Significant difference in scale characteristics was found between LT and ST fish groups. Two scale variables were found that provided an acceptable level of discrimination. However, the fish could not be discriminated individually, due to an overlap in the distribution of scale variables. Accordingly, further examination is still inquired to find an effective scale characteristic, which can detect the individual differences.

3. Salmon Habitat and Ecosystem

3.1 Physical-biological Interaction and Productivity

Chlorophyll-*a* concentration in the southern Okhotsk Sea in late autumn: a comparison between 1993 and 1996. Shiomoto, A., H. Tanaka, J. Seki, I. Shimizu, and Y. Shibuya. 1998. Plankton Biol. Ecol., 45: 139-149. [National Research Institute of Far Seas Fisheries, 5-7-1 Orido, Shimizu, Shizuoka 424, Japan]

The chlorophyll-*a* (Chl-*a*) concentrations in late autumn within the upper mixed layer (generally shallower than 30-50 m) was found to be near homogenous. Chl-*a* concentrations within and below the upper mixed layer were significantly higher in 1996 than in 1993. The Chl-*a* concentrations within the mixed layer was 0.79±0.29 $\mu g\ l^{-1}$ (mean ±1SD, n=71) in 1993 and 1.53 ±0.61 $\mu g\ l^{-1}$ (n=41) in 1996, and those below the layer was 0.04±0.61 $\mu g\ l^{-1}$ (n=97) in 1993 and 0.09±0.10 $\mu g\ l^{-1}$ (n=59) in 1996. The mean values within and below the upper mixed layer in 1996 were approximately two times higher than in 1993. The difference between the two years, calculated through mean values, was found to be 0.74 $\mu g\ l^{-1}$ and 0.05 $\mu g\ l^{-1}$. Possible contributing factors responsible for such differences in Chl-*a* concentrations are discussed. Differences in the grazing impact of macrozooplankton (mainly copepods) were identified as an important factor contributing to the observed difference in Chl-*a* concentrations between the two years.

Abundance of micro-animals (especially, harpacticoid copepods) during the release of juvenile chum salmon, *Oncorhynchus keta* and adult return rate into the coastal area off Mashike, Japan Sea, northern Hokkaido. Hayano, H., H. Asami, and K. Hirano. 1997. Sci. Rep. Hokkaido Fish Hatchery, 51: 11-16. In Japanese with English summary. [Hokkaido Fish Hatchery, Kitakashiwagi 3, Eniwa, Hokkaido 061-14, Japan]

Abundance of micro-animals was investigated during the release of chum salmon from 1990 to 1992 into a shallow coastal area of Mashike, northern Japan Sea. Total micro-animal density fluctuated between 10-2,600 individuals.m^{-3} from 1990 to 1992. Harpacticoid copepods (*Harpacticus* spp.), important preys of juvenile chum salmon, were predominant in 1991 and 1992, but low level in 190. In 1991, water temperature from January to March was higher than in 1991 or 192. Juvenile chum salmon released into the Shokanbetsu River during this investigation returned after 2-5 years. Rates of 2-4 years old adult returns in 1990, 1991, and 1992 releasing year groups were 0.09%, 0.31%, and 0.34%, respectively. The low return rate in 1990 may have been due to low density of harpacticoid copepods during the release period.

Distribution of zooplankton communities during spring to early summer in the Pacific coastal waters near Hiroo, Hokkaido. Seki, J., and I. Shimizu. 1997. Bull. Plankton Soc. Jpn., 44: 21-30. In Japanese with English summary. [Research Division, National Salmon Resources Center, Fisheries Agency of Japan, 2-2 Nakanoshima, Toyohira-ku, Sapporo 062, Japan]

Temporal and spatial changes in the zooplankton communities with environmental variables were investigated in the Pacific coastal waters of the central Hokkaido, Japan. Zooplankton were collected with simultaneously horizontal tow nets (30 cm mouth diameter, 180 cm long with 0.27 mm mesh) from 4 to 6 different layers (0, 1, 3, 5, 10 and 20 m depth), depending on the bottom depth at each station, from May 13 to July 8, 1986. Surface water temperature was increased from 4°C on May 13 to 14°C on July 8. A thermocline developed around 10 m depth on June 3-4 and ascended above 5 m on June 24-25. The peak of zooplankton abundance in their vertical distribution was 4 x 103 inds m^{-3} on May 13 and increased to 19 x 103 inds m^{-3} on June 3-4. After that it which decreased to 5 x 103 inds m^{-3} by July 8. Some high density areas appeared during June 3-4 to July 8. In almost all cases, these high density areas were formed in the upper thermocline, which would supply preferable food condition for juvenile chum salmon. The zooplankton communities could be classified into ten groups by the cluster analysis. One of the species *Pseudocalanus* spp., *Acartia tumida* and *Acartia longiremis* dominated in the six groups of them. These copepods are cold-water species and their distribution in time and space were slightly different each other.

4. Miscellaneous

Effect of modified magnetic field on the ocean migration of maturing chum salmon, *Oncorhynchus keta*. Yano, A., M. Ogura, A. Sato, Y. Sakai, Y. Shimizu, N. Baba, and K. Nagasawa. Marine Biology, 129: 523-530. [Graduate School of Science and Technology, Chiba University, Inage, Chiba 263, Japan]

To investigate the role of magnetic compass orientation in oceanic migrating chum salmon, an ultrasonic telemetry study was carried out in the western North Pacific off the coast of Kushiro, Hokkaido. Four salmon were fitted with a tag that generated an artificial magnetic field and modified the geomagnetic field around the head of the fish. Initially, the free-ranging salmon with stomach-implanted ultrasonic transmitters were tracked for a period of several hours before the magnetic field was altered for a period of 16 h. The generator produced an alternating magnetic field intensity of about 6 gauss, with polarity which reversed every 11.25 min. There was no observable effect on the horizontal and vertical movements of the salmon when the magnetic field was modified. However, it was noted that salmon showed their swimming speed significantly before changing direction, regardless of whether the fish were swimming under the normal geomagnetic field or whether they were swimming under the modified field.

5. Appendix

Bibliography of Salmonids Published in Japan, 1997

This current salmonid bibliography has covered scientific publications in Japan in 1997. 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:

Ecology-General

Takami, T., and T. Aoyama. 1997. White-spotted charr predation on juvenile chum salmon in coastal waters in northern Japan. Sci. Rep. Hokkaido Fish Hatchery, 51: 57-61. [Hokkaido Fish Hatchery, Kitakashiwagi 3, Eniwa, Hokkaido 061-14, Japan]

Takami, T., F. Kitano, and S. Nakano. 1997. High water temperature influences on foraging responses and thermal deaths of Dolly Varden *Salvelinus malma* and white-spotted charr *S. leucomaenis* in a laboratory. Fisheries Science, 63: 6-8. [Hokkaido Fish Hatchery, Makkari Branch, Makkari, Hokkaido 048-16, Japan]

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