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Japanese Bibliography in 2010-2011 for NPAFC Science Plan

by

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ABSTRACT

This bibliography listed original papers and documents published in 2010-2011 by Japanese scientists and their collaborators in order to review Japanese national researches for the 2011-2015 NPAFC Science Plan. The bibliography covered 26 papers with abstracts, corresponding to research components of the NPAFC Science Plan.

BACKGROUND

In 2010, the Science Sub-Committee (SSC) of the North Pacific Anadromous Fish Commission (NPAFC) developed a new five-year Science Plan (2011-2015) (Anonymous 2010). The SSC identified an overarching research theme "Forecast of Pacific Salmon Production in the Ocean Ecosystems under Changing Climate" and five research components: 1) Migration and survival mechanisms of juvenile salmon in the ocean ecosystems; 2) Climate impacts on Pacific salmon production in the Bering Sea (BASIS) and adjacent waters; 3) Winter survival of Pacific salmon in the North Pacific Ocean; 4) Biological monitoring of key salmon populations; and 5) Development and application of stock identification methods and models for management of Pacific salmon.

The national research plan by Japan was established in March 2011 to correspond to the new NPAFC Science Plan (Fisheries Agency of Japan 2011). The primary goal is to accomplish sustainable salmon fisheries with the conservation of wild and hatchery stocks in the North Pacific ecosystems. To review Japanese national researches for the NPAFC Science Plan, this bibliography listed original papers and documents published in 2010-2011 by Japanese scientists and/or their collaborators. The bibliography includes abstracts for all articles.

Anonymous. 2010. North Pacific Anadromous Fish Commission Science Plan 2011-2015. NPAFC Doc. 1255. 34 pp. Committee on Scientific Research and Statistics (CSRS), North Pacific Anadromous Fish Commission, Suite 502, 889 West Pender Street, Vancouver, B. C., V6C 3B2 Canada. (Available at www.npafc.org).

Fisheries Agency of Japan. 2011. Japanese salmon research under the NPAFC Science Plan 2011-2015. NPAFC Doc. 1311. 3 pp. (Available at www.npafc.org).

BIBLIOGRAPHY

Component 1: Migration and Survival Mechanisms of Juvenile Salmon in the Ocean Ecosystems

Saito, T., T. Kaga, E. Hasegawa, H. Saito, and K. Nagasawa. 2011. Effects of juvenile size at release and early marine growth on adult return rates for Hokkaido chum salmon (*Oncorhynchus keta*) in relation to sea surface temperature. Fisheries Oceanography 20 (4): 278-293.

Using path analyses, we investigated relationships between size at release from hatcheries, the early marine growth of juveniles, and adult return rates for chum salmon from five river stocks of Hokkaido, Japan, in relation to sea surface temperature during ocean residence. Marine growth was estimated using scales collected from 11760 adults of age 0.3 (1980-2004). The growth and survival of each stock appeared to have a different suite of regulatory processes. Inter-annual variability in return rates was mainly regulated by size at release in two stocks from the Sea of Okhotsk. A similar relationship was found in one stock from the Sea of Japan, but growth during coastal residency also affected their return rates. In two stocks from the Pacific coast of Hokkaido, variability in return rates was not related to size at release or to the coastal growth of juveniles, but with offshore growth in the Sea of Okhotsk, the nursery area for juveniles after leaving Japanese coastal waters. Whereas coastal growth tended to be negatively correlated with size at release in some stocks, offshore growth was positively associated with the August-November sea surface temperature in all stocks. This study confirmed that mortality of juvenile salmon occurred in two phases, during the coastal residency and the late period of the growing season, but the relative importance of both phases varied by stock and region, which probably regulated year-class strength of Hokkaido chum salmon.

Saito, T., I. Shimizu, J. Seki, T. Kaga, E. Hasegawa, H. Saito, and K. Nagasawa. 2010. Can research on the early marine life stage of juvenile chum salmon *Oncorhynchus keta* forecast returns of adult salmon? A case study from eastern Hokkaido, Japan. Fisheries Science 76 (6): 909-920.

To examine the efficacy of juvenile salmon research as a tool for forecasting adult returns, the results from a study on the early marine life stage of juvenile chum salmon, conducted in the Nemuro Strait during 1999-2002 (i.e., 1998-2001 brood years), were compared with the return rates of adult salmon. Among the four brood years, the 2000 brood year (i.e., salmon migrating to the sea in 2001) was previously reported as showing higher abundance, higher growth rate and better somatic condition during the coastal residency period. Consequently, we expected it to have the highest return rate, under a hypothesis that juvenile survival in coastal residency regulates brood-year strength. Contrary to this expectation, the 2000 brood year had almost the lowest return rate. Alternatively, a statistical model in which sea surface temperature during the first year of marine life and size at release were utilized as explanatory variables reconstructed

the actual variability in return rates more accurately than that based on the early marine life stage. Possible reasons for the discrepancy between the results of the juvenile salmon research and adult returns are discussed, and we suggest improvements for future research on juvenile salmon.

Torao, M., K. Takeuchi, Y. Sasaki, K. Kasugai, Y. Murakami, and M. Nagata. 2010. Seasonal timing of downstream migration and migrating speed of the hatchery and wild pink salmon, *Oncorhynchus gorbuscha* fry in the Tohoro River, eastern Hokkaido, Japan. Scientific Reports of the Hokkaido Fish Hatchery 64: 7-15 (In Japanese with English abstract).

Downstream migration of wild and hatchery pink salmon fry, *Oncorhynchus gorbuscha*, was investigated in 2007 and 2008 in Tohoro River at Nemuro Strait, Eastern Hokkaido, Japan. All pink salmon fry released from the hatchery were marked by the Alizarin Complexone (ALC) at the eyed-stage. Marked pink salmon fry were released from Tohoro Hatchery (45 km up the river mouth) from late March to mid-April. Pink salmon fry were collected by a rotary-screw trap at the rower site (2.5 km up the river mouth) in Tohoro River during late March to late May in 2007 and 2008. In 2007 and 2008, 9.1% and 48.8% of wild fish (no marked) was contained in the collected pink salmon fry, respectively. Downstream migrant wild pink salmon fry was found from late March to mid-May in Tohoro River, and the peak period for fry migration was early April both in 2007 and 2008. The main group of ALC marked fish were recaptured on three to six days after the release at the lower site. The water temperature in Tohoro River was changed from 2 °C to 14 °C during the release season, but the water temperature or seasonal timing of release have little effect on the migration speed for pink salmon fry.

Component 2: Climate Impacts of Pacific Salmon Production in the Bering Sea (BASIS) and Adjacent Waters

Fukuwaka, M., T. Kaga, and T. Azumaya. 2011. Regional differences in climate factors controlling chum and pink salmon abundance. ICES Journal of Marine Science 68 (6): 1131-1137.

Chum and pink salmon abundances vary on a decadal time-scale. We examined the relationship between large-scale climate indices (Os), regional climate factors (RFs), and rates of change in regional catches (RCs) of chum and pink salmon in five regions of the North Pacific. Correlation coefficients of RCs with RFs were larger than those of RCs with CIs, although the correlation coefficient of particular variables varied among regions. Climate affected salmon stocks as indicated by significant relationships with various terrestrial and ocean climate factors on a regional scale. These results suggest that no single CI or RF controls salmon abundance in all regions; however, global climate changes could affect regional climate directly and regional salmon abundance indirectly. A warming trend in the North Pacific might affect the long-term change in salmon abundance. The mechanisms controlling regional salmon abundance must be

understood better to forecast successfully future conditions for Pacific salmon stocks, because the response of salmon stocks to global climate change varies among regions.

Fukuwaka, M., S. Sato, O. Yamamura, O. Sakai, T. Nagasawa, A. Nishimura, and T. Azumaya. 2010. Biomass and mortality of chum salmon in the pelagic Bering Sea. Marine Ecology Progress Series 403: 219-230.

To provide a key piece of information for understanding the functioning of the Bering Sea pelagic ecosystem, we estimated the biomass of immature chum salmon in the Bering Sea basin in autumn using a return-at-age analysis incorporated with the results of genetic stock identification studies. The estimated biomass was 742000 t in 2002 and 617000 t in 2003, which is possibly an underestimate because of the uncertainty of trawl selectivity parameters used in the estimation. Although chum salmon has been the dominant nekton species in the pelagic ecosystem of the Bering Sea basin in recent years, biomass estimates for the species were smaller than one-tenth of the maximum biomass of walleye pollock in the 1980s. Previous studies have highlighted the importance of the huge biomass of mesopelagic planktivores, such as myctophid fishes and gonatid squid, to the ecosystem function of the pelagic Bering Sea. Planktivorous Pacific salmon including chum and pink salmon may also play a significant role as competitors and predators of small planktivores, thus affecting the dynamics of ecosystem function and nekton community structure in the pelagic Bering Sea.

Hoshi N., K. Sakaoka, T. Abe, Y. Kamei, S. Takagi. 2010. Results of 2009 Salmon Research Cruises of the *Oshoro maru*. NPAFC Doc. 1226. 20 pp. (Available at www.npafc.org).

In order to clarify the oceanic structure and marine ecosystem, oceanographic observations and fishing surveys (including for salmonids) were conducted in the Northwest Pacific Ocean (along 155°E), in the Central North Pacific Ocean (along 47°N), in the sea area around the Aleutian Islands and in the Bering Sea. Each survey was conducted during the Cruise #201 in May and the Cruise #202 from June to July, 2009. The Polar Front was located at 44°N and the Subarctic Boundary was located at 40°N in the 155°E research line. Three drift gillnet were conducted along 155°E in May during the Cruise #201 (OSG0901: 43°-33’N, OSG0902: 41°-45’N, OSG0903: 37°-05’N). A total of 70 chum salmon and 552 pink salmon were caught by the drift gillnet operations. The CPUE value of chum salmon was highest at 43°-33’N, on the other hand, that of pink salmon was highest at 41°-45’N. No salmonids were caught 37°-05’N. A total of 14 chum and 609 pink salmon were caught by four hook-and-line gear samplings. Almost all chum salmon caught along 155°E in May were mature, and this result was same as before. The 47°N latitude line between 160°E and 175.5°W longitude in the North Pacific, the surface temperature got colder from east to west. Temperature under 2°C was observed about depth of 100db at 160°E. The halocline was observed about depth of 150db in this research line. Four drift gillnets and nine hook-and-line gear samplings were conducted along the 47°N line in the North Pacific. One surface long-line and three hook-and-line gear samplings were conducted around the sea area of

Aleutian Islands during the Cruise #202 -Leg 1.A total of 109 sockeye, 230 chum, 895 pink, 46 coho and 10 steelhead salmon were collected by every sampling gear. Three drift gillnets, one surface long-line and 10 hook-and-line gear samplings were conducted in the Bering Sea during the Cruise #202-Leg 2. A total of 76 sockeye, 302 chum, 1909 pink salmon and one coho and three chinook salmon were collected by drift gillnets and hook-and-line gear samplings.

Ishihara, T., J. Seki, T. Koide, and M. Fukuwaka. 2010. International salmon research aboard the R/V *Wakatake maru* in the central North Pacific Ocean and Bering Sea during the summer of 2010. NPAFC Doc. 1265. 16 pp. (Available at www.npafc.org).

An annual high-seas salmonid research cruise was conducted in the central North Pacific Ocean and Bering Sea from June 10 to July 19, 2010, onboard 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. Average sea surface temperature in the central North Pacific Ocean in 2010 was 8.3°C, which was cooler by 1°C than the average temperature in 2009. The Subarctic Boundary was located between 41°N and 42°N, which was further north of its position in 17 of the previous 19 years. In the central Bering Sea, average sea surface temperature in 2010 was 6.5°C, which was 0.1°C warmer than in 2009. At 24 experimental fishing stations, a total of 5,816 salmonids was caught by longline and gillnet: 790 fish in the central North Pacific and 5,026 fish in the central Bering Sea. In the central North Pacific, coho salmon was the most abundant species (46.6% of the salmonid catch), followed by chum (31.9%), pink (10.1%), steelhead (6.6%), sockeye (3.3%), and chinook salmon (1.5%). In the Bering Sea, chum salmon was the most abundant species (81.3% of the salmonid catch), followed by sockeye (15.5%), pink (2.2%), chinook (1.0%), and coho salmon (0.02%). A total of 1,401 salmonids was disk tagged during the survey, which included 18 sockeye, 102 chum, 21 pink, 84 coho, and one chinook salmon, and nine steelhead released in the central North Pacific and 74 sockeye, 1,067 chum, 14 pink, and 11 chinook salmon released in the Bering Sea. Snouts from 14 adipose fin-clipped steelhead were collected for later potential recovery of coded-wire tags. Other salmonid research activities included sampling for total lipid content, otolith thermal marks, genetic stock identification, food habits, and stable isotopes.

Kaga, T and S. Sato. 2010. Total lipid contents and RNA/DNA ratios of sockeye, chum and pink salmon in the North Pacific Ocean and the Bering Sea during the summer of 2009. NPAFC Doc. 1262. 12 pp. (Available at www.npafc.org.).

This document reports the total lipid contents and RNA/DNA ratios of sockeye, chum and pink salmon which were caught in the North Pacific Ocean and the Bering Sea during the summer (June-July) of 2009. A total of 526 salmon which includes 106 sockeye, 180 chum and 240 pink salmon, was examined for total lipid contents. A total of 180 salmon which includes 51 sockeye, 74 chum and 55 pink salmon, was examined for RNA/DNA ratio. Older sockeye and chum salmon had higher total lipid content than younger fish. Total lipid content correlated positively

with fork length in sockeye and chum salmon, but did not in pink salmon. RNA/DNA ratio negatively correlated with fork length in chum salmon. Comparing the RNA/DNA ratios in the present results with a past study, RNA/DNA ratios in 2009 was lower than that in 1994 and 1995. Total lipid content of chum salmon in 2009 was significantly higher than the mean total lipid content from 1998 to 2007, lipid storage state of chum salmon in 2009 was regarded as high. These biochemical parameters of pink salmon were higher than sockeye and chum salmon at the same ocean age. This difference in biochemical parameters among salmon species might reflect the difference in life history that the pink salmon had a shorter ocean life than sockeye and chum salmon.

Kamei, Y., K. Sakaoka, N. Hoshi, T. Abe, K. Imai, and S. Takagi. 2011. Results of 2010 Salmon Research by the Oshoro-maru. NPAFC Doc. 1308. 19 pp. (Available at www.npafc.org).

In order to accumulate oceanographic and biological data (including salmonids) and to clarify the oceanic structure and marine ecosystem, The T/V *Oshoro maru* conducted oceanographic observations and fishing surveys in the Northwest Pacific Ocean (along the 155°E longitude line), Central North Pacific Ocean (along the 165°E longitude line), and in the area of the Aleutian Islands. Each survey was conducted during the Cruise #215 in May, and the Cruise #216 from June to July, 2010. Thirteen oceanographic observations and four drift gillnet surveys were conducted along the 155°E during the Cruise #215 in May. The Polar Front was observed in the vicinity of 43°-45'N and subtropical and subarctic water were mixed intricately in the Transition Domain. Pink salmon was dominant species at 43°-04'N and 41°-44'N. Chum salmon was abundant at 43°-04'N and 41°-44'N, on the other hand, pink salmon was the dominantly abundant at 41°-44'N. The fork lengths of chum salmon collected by C-gear gillnet ranged between 460-700mm F.L., and those of pink salmon ranged between 320-470mm F.L.. 94.4% of chum salmon were adult fish. Fourteen oceanographic observations and five drift gillnet surveys were conducted along the 165°E during the Cruise #216 from late June to early July. The Polar Front was observed in the vicinity of 45°-45'N. The Subarctic Boundary was observed in the vicinity of 41°N. The Tradition Domain was thought to be located between 41°N and 45°-45'N. 43 chum, 317 pink, and eleven coho salmon were collected by drift gillnet surveys. Almost salmonids were collected at 46°-27'N, and most dominant salmonids was pink salmon. Fork lengths of chum salmon collected by C-gear gillnet ranged between 330-660mm F.L., and those of pink salmon ranged between 410-500mm F.L.. Adult chum salmon were collected only at 46°-27'N. To collect salmon samples extensively and to collect fresh salmon blood and various tissues, six surface longline and fifteen hook-and-line gear samplings were conducted during the Cruise #215 and #216-Leg 2, 3. A total of 34 sockeye, 122 chum, 555 pink, 61 coho, and four steelhead salmon were collected in five research areas during two cruises.

Kishi, M. J., M. Kaeriyama, H. Ueno, and Y. Kamezawa. 2010. The effect of climate change on the growth of Japanese chum salmon (*Oncorhynchus keta*) using a bioenergetics

model coupled with a three-dimensional lower trophic ecosystem model (NEMURO). Deep-Sea Research Part II-Topical Studies in Oceanography 57 (13-14): 1257-1265.

From the 1970s to 1990s, a reduction in the body size of Japanese chum salmon (*Oncorhynchus keta*) was observed. To investigate this body size reduction in the North Pacific, we developed a bioenergetics model for chum salmon coupled with the results from a lower trophic ecosystem model embedded into a three-dimensional global model. In the bioenergetics model, respiration and consumption terms are assumed to be functions of water temperature and prey zooplankton density, which are the determining factors of the reduction of body size. The model reproduced the body size of the 1972 and 1991 year classes of chum salmon. The reproduced body size of the 1972 year class was larger than that of 1991 year class, and this result agrees with observations from the Bering Sea. Our model also reproduced the body size trend from 1970 to 2000. The prey density, especially in the eastern North Pacific, had a greater influence on the change of body size than did the SST. This suggests that the size reduction of Japanese chum salmon in the 1990s was partly affected by changes in prey zooplankton density. In the context of the global warming scenario, we discuss changes in the migration route of chum salmon and predict that the population of Japanese chum salmon experience significant declines over this century.

Morita, K. 2011. Body size trends along vertical and thermal gradients of chum salmon in the Bering Sea during summer. Fisheries Oceanography 20 (3): 258-262.

Relationships between the vertical distribution and thermal habitat, and body size of chum salmon *Oncorhynchus keta* were studied in the Bering Sea in summer using trawl surveys at various depths. Chum salmon abundance decreased with increasing depth, but the patterns of decrease differed between size groups. The abundance of small salmon fell rapidly with depth, whereas that of large salmon decreased gradually to 40 m depth, and abruptly below that. The average fork length of chum salmon collected from each trawl correlated positively with trawl net depth and negatively with water temperature. Since the optimal temperature for growth decreases with body size in this species, the observed body size-related vertical habitat use by chum salmon may indicate size-dependent thermal preferences.

Morita, K. 2010. Vertical distribution of Pacific salmon in the central Bering Sea in summer 2007. NPAFC Doc. 1266. 4 pp. (Available at www.npafc.org).

The vertical distribution of Pacific salmon *Oncorhynchus* spp., sampled by trawl net, in the central Bering Sea in summertime was examined. The abundance of Pacific salmon caught decreased with increasing depth and the majority of Pacific salmon were caught within the upper 50 m. The inter-specific variation in vertical distribution was relatively small.

Morita, K., M. Fukuwaka, and N. Tanimata. 2010. Age-related thermal habitat use by Pacific salmon *Oncorhynchus* spp. Journal of Fish Biology 77 (4): 1024-1029.

Age-related thermal habitat use by sockeye *Oncorhynchus nerka*, chum *Oncorhynchus keta*

and pink *Oncorhynchus gorbuscha* salmon was examined using trawl data obtained in spring in the North Pacific Ocean. Thermal habitat use differed by species and age. Larger and older fishes inhabited cooler areas, whereas smaller and younger fishes inhabited warmer areas.

Morita, K., M. Fukuwaka, and N. Tanimata, and O. Yamamura. 2010. Size-dependent thermal preferences in a pelagic fish. OIKOS 119 (8): 1265-1272.

Large fish often inhabit colder waters than small fish. Using a simple bioenergetic model, we found that the optimal temperature for growth should decrease with increasing body size. We predicted that this mechanism would produce an ontogenetic change in thermal preference and then tested our predictions with Pacific salmon, *Oncorhynchus* spp. In a laboratory experiment, the slope of a regression of growth increment on initial size became steeper with increasing temperature, so that the optimal temperature for growth decreased with increasing body size. In field observations, larger and older salmon inhabited cooler areas, whereas smaller and younger salmon inhabited warmer areas. These patterns were consistent with a size-dependent effect of temperature on condition factor, a parameter shown experimentally to be a measure of the most recent growth performance. Temperatures for maximising condition factor were lower for larger fish. Thus, an ontogenetic change in individual thermal preference toward cooler areas maximises the growth performance of fish, and the negative effects of climate warming on growth are hypothesised to be more severe for larger fish.

Seo, H., H. Kudo, and M. Kaeriyama. 2011. Long-term climate-related changes in somatic growth and population dynamics of Hokkaido chum salmon. Environmental Biology of Fishes 90 (2): 131-142.

We used multiple regression and path analysis to examine the effects of regional and larger spatial scales of climatic/oceanic conditions on the growth, survival, and population dynamics of Hokkaido chum salmon (*Oncorhynchus keta*). Variability in the growth of chum salmon at ages 1 to 4 was estimated from scale analysis and the back-calculation method using scales of 4-year-old adults returning to the Ishikari River in Hokkaido, Japan, during 1943-2005. Growth of chum salmon at age 1 was less during the period from the 1940s to the mid-1970s compared to the period from the mid-1980s to the present. On the other hand, growth of chum salmon at ages 2, 3, and 4 has declined since the 1980s. Path analysis indicated that growth at age 1 in the Okhotsk Sea was directly affected by warmer sea surface temperatures associated with global warming. The increased growth at age 1 led directly to higher survival rates and indirectly to larger population sizes. Subsequently, in the Bering Sea, the larger population size was directly associated with decreased growth at age 3 and indirectly associated with shorter adult fork lengths despite the lack of relationships among sea surface temperature, zooplankton biomass, and growth at ages 2 to 4. Therefore, higher growth at age 1 related to global warming positively affected the survival rate of juvenile chum salmon in the Okhotsk Sea. The higher survival rates in turn appear to be causing a population density-dependent effect on growth at ages 2 to 4 and maturation in the Bering Sea due to limited carrying capacity.

Toge, K., R. Yamashita, K. Kazama, M. Fukuwaka, O. Yamamura, and Y. Watanuki. 2011. The relationship between pink salmon biomass and the body condition of short-tailed shearwaters in the Bering Sea: can fish compete with seabirds? Proceedings of the Royal Society B-Biological Sciences 278 (1718): 2584-2590.

Seabirds and large fishes are important top predators in marine ecosystems, but few studies have explored the potential for competition between these groups. This study investigates the relationship between an observed biennial change of pink salmon (*Oncorhynchus gorbuscha*) biomass in the central Bering Sea (23 times greater in odd-numbered than in even-numbered years) and the body condition and diet of the short-tailed shearwater (*Puffinus tenuirostris*) that spends the post-breeding season there. Samples were collected with research gill nets over seven summers. Both species feed on krill, small fishes and squid. Although the mean pink salmon catch per unit effort (in mass) over the study region was not related significantly with shearwater's stomach content mass or prey composition, the pink salmon biomass showed a negative and significant relationship with the shearwater's body mass and liver mass (proxies of energy reserve). We interpret these results as evidence that fishes can negatively affect mean prey intake of seabirds if they feed on a shared prey in the pelagic ecosystem.

Component 3: Winter Survival of Pacific Salmon in the North Pacific Ocean Ecosystem

No publication

Component 4: Biological Monitoring of Key Salmon Population

Ando, D., K. Shimoda, Y. Shinriki, H. Urabe, T. Aoyama, and M. Nakajima. 2010. Inflexibility of vertebral number in chum salmon *Oncorhynchus keta*. Fisheries Science 76 (5): 761-767.

Chum salmon eggs from the Chitose and Shiriuchi rivers in Hokkaido, northern Japan, were incubated under identical conditions with the aim of comparing vertebral number (V(N)) to that reported archived data from the 1950s. The comparison revealed that mean V(N) of salmon from the Shiriuchi River has remained unchanged for 50 years and is higher than that from the Chitose River. The V(N) in the Chitose River salmon was found to be significantly higher than that recorded in the archival data. The variation in the mean V(N) of chum salmon fry collected during different seasons and years in the Chitose River falls within a range that has remained constant, suggesting that the difference between the values obtained in our study and the archival data may be due to differences in the timing of egg collection. These results indicate that the mean V(N) of chum salmon has been stable for a long period. Incubation experiments under

identical conditions are a useful tool for examining changes in genetic structure and detecting the essential properties of populations.

Fukuwaka, M., T. Ishihara, M. Sakai, and Y. Kamei. 2010. Salmon stock assessment in the North Pacific Ocean, 2010. NPAFC Doc. 1264. 9 pp. (Available at www.npafc.org).

Results of annual research cruises on salmon stock assessment conducted by Japan in the summer of 2010 were summarized. Three Japanese salmon research vessels (*Oshoro maru*, *Kaiun maru* and *Wakatake maru*) conducted oceanographic observations, 47 gillnet (2,324 tans), 29 longline (800 hachi) and 15 hook-and-line fishing operations in the North Pacific and the Bering Sea from May to early August. Mean sea surface temperature and abundance of salmonids in 2010 were compared to those from 1992 to 2009. Mean sea surface temperature at gillnet research stations in 2010 were lower than the mean of 1992-2009 in the Bering Sea. A total of 7,739 salmonids was caught during fishing operations including 4,788 chum (61.9%), 1,486 pink (19.2%), 842 sockeye (10.9%), 488 coho (6.3%), 68 chinook salmon (0.9%), and 67 steelhead trout (0.9%). In the Bering Sea, mean CPUE of sockeye salmon in the summer of 2010 was higher than the mean in 1992-2010, while mean CPUEs of chum and pink salmon were lower. Mean CPUEs of other salmonids including coho, chinook salmon and steelhead trout were at a low level in 2010.

Onuma, T. A., K. Makino, H. Ando, M. Ban, M. Fukuwaka, T. Azumaya, and A. Urano. 2010. Expression of GnRH genes is elevated in discrete brain loci of chum salmon before initiation of homing behavior and during spawning migration. General and Comparative Endocrinology 168 (3): 356-368.

The previous studies suggested the importance of gonadotropin-releasing hormones (GnRHs) for initiation of spawning migration of chum salmon, although supporting evidence had been not available from oceanic fish. In farmed masu salmon, the amounts of salmon GnRH (sGnRH) mRNAs in the forebrain increased in the pre-pubertal stage from winter through spring, followed by a decrease toward summer. We thus hypothesized that gene expression for GnRHs in oceanic chum salmon changes similarly, and examined this hypothesis using brain samples from winter chum salmon in the Gulf of Alaska and summer fish in the Bering Sea. They were classified into sexually immature and maturing adults, which had maturing gonads and left the Bering Sea for the natal river by the end of summer. The absolute amounts of GnRH mRNAs were determined by real-time PCRs. The amounts of sGnRH mRNA in the maturing winter adults were significantly larger than those in the maturing summer adults. The amounts of sGnRH and chicken GnRH mRNAs then peaked during upstream migration from the coast to the natal hatchery. Such changes were observed in various brain loci including the olfactory bulb, terminal nerve, ventral telencephalon, nucleus preopticus parvocellularis anterioris, nucleus preopticus magnocellularis and midbrain tegmentum. These results suggest that sGnRH neurons change their activity for gonadal maturation prior to initiation of homing behavior from the Bering Sea. The present study provides the first evidence to support a possible involvement of neuropeptides

in the onset of spawning migration.

Onuma, T. A., M. Ban, K. Makino, H. Katsumata, W. W. Hu, H. Ando, M. Fukuwaka, T. Azumaya, and A. Urano. 2010. Changes in gene expression for GH/PRL/SL family hormones in the pituitaries of homing chum salmon during ocean migration through upstream migration. General and Comparative Endocrinology 166 (3): 537-548.

Gene expression for growth hormone (GH)/prolactin (PRL)/somatolactin (SL) family hormones in the pituitaries of homing chum salmon were examined, because gene expression for these hormones during ocean-migrating phases remains unclear. Fish were collected in the winter Gulf of Alaska, the summer Bering Sea and along homing pathway in the Ishikari River-Ishikari Bay water system in Hokkaido, Japan in autumn. The oceanic fish included maturing adults, which had developing gonads and left the Bering Sea for the natal river by the end of summer. The absolute amounts of GH, PRL and SL mRNAs in the pituitaries of the maturing adults in the summer Bering Sea were 5- to 20-fold those in the winter Gulf of Alaska. The amount of GH mRNA in the homing adults at the coastal seawater (SW) areas was smaller than that in the Bering fish, while the amount of PRL mRNA remained at the higher level until fish arrived at the Ishikari River. The gill Na(+),K(+)-ATPase activity in the coastal SW fish and the plasma Na(+) levels in the brackish water fish at the estuary were lowered to the levels that were comparable to those in the fresh water (FW) fish. In conclusion, gene expression for GH, PRL and SL was elevated in the pituitaries of chum salmon before initiation of homing behavior from the summer Bering Sea. Gene expression for GH is thereafter lowered coincidently with malfunction of SW adaptability in the breeding season, while gene expression for PRL is maintained high until forthcoming FW adaptation.

Shimoda, K., Y. Shinriki, K. Kasugai, and N. Hoshino. 2010. Variation in morphological characteristics of pink salmon in Hokkaido. Nippon Suisan Gakkaishi 76 (1): 20-25. (In Japanese with English abstract).

The variation in morphological characteristics of adult pink salmon *Oncorhynchus gorbuscha* collected in nine rivers in Hokkaido, Japan was surveyed in 2005 and 2006. Results of the cluster analysis and discriminant analysis suggested that the difference in meristic counts between the years was greater than that among rivers. The difference in the numbers of dorsal fin rays, anal fin rays and vertebrae between years was greater than that among rivers within year. There was a significant difference in the count of pectoral fin rays and gill rakers of the specimens among rivers, but not between years. Principal component analysis revealed that the 2006 year fish have more dorsal fin rays, anal fin rays and vertebrae, than the 2005 year fish.

Suzuki, J., R. Murata, K. Sadamasu, and J. Araki. 2010. Detection and identification of *Diphyllobothrium nihonkaiense* plerocercoids from wild Pacific salmon (*Oncorhynchus* spp.) in Japan. Journal of Helminthology 84 (4): 434-440.

We investigated the risk of diphyllobothriasis from ingestion of wild Pacific salmon in Japan

by surveying Diphyllobothrium plerocercoids in 182 salmon samples obtained from Japan. The plerocercoids were not detected in chum salmon (*Oncorhynchus keta*) (0/26), called Akizake in Japan, caught between September and November. However, the detection rate of plerocercoids in chum salmon, called Tokishirazu in Japan, caught between early April and June, was 51.1% (24/47) with an average of two plerocercoid larvae per fish. The detection rates of cherry salmon (*Oncorhynchus masou*) and pink salmon (*Oncorhynchus gorbuscha*) were 12.2% (10/82) and 18.5% (5/27), respectively, and the average number of plerocercoids per fish was 0.45 (37 larvae/82 fishes) and 0.22 larvae (6 larvae/27 fishes), respectively. Plerocercoids isolated from *O. keta* and *O. masou* were identified as Diphyllobothrium nihonkaiense on the basis of molecular analysis of the cox1 and nad3 genes. Moreover, four tapeworms (three from *O. keta* and one from *O. masou*) were obtained by infecting golden hamsters with plerocercoids. The morphological features of these tapeworms were similar to those of D. nihonkaiense isolated from humans. Therefore, we think that *O. keta* and not *O. masou* is the most important source of plerocercoid infections in Japan.

Yokoyama, Y., Y. Koshino, K. Miyamoto, H. Kudo, S. Kitada, and M. Kaeriyama. 2010. Estimating the spawning escapement of pink salmon *Oncorhynchus gorbuscha* using the area-under-the-curve method in the Rusha River of the Shiretoko Peninsula, Hokkaido Island. Nippon Suisan Gakkaishi 76 (3): 383-391. (In Japanese with English abstract).

Pacific salmon *Oncorhynchus* spp. plays a role in sustaining the biodiversity and production of the terrestrial ecosystem. Accurate estimation of the escapement and spawning dynamics is important for the quantifying the effect of salmon on the riparian ecosystem. The objective of this paper is to estimate accurately the escapement and spawning dynamics of wild pink salmon *O. gorbuscha* at the Rusha River in the Shiretoko World Natural Heritage area in 2006-2008. The escapement of pink salmon was estimated by the area-under-the-curve method (AUC) with the standard error based on the bootstrap method. The estimated escapement indicated appropriate results. The carrying capacity of spawning redds, however, was far lower than escapements in the available spawning area.

Component 5: Development and Applications of Stock Identification Methods and Models for Management of Pacific Salmon

Beacham, T. D., J. R. Candy, E. Porszt, S. Sato, and S. Urawa. 2011. Microsatellite identification of Canadian sockeye salmon rearing in the Bering Sea. Transaction of the American Fisheries Society 140 (2): 296-306.

The stock composition of sockeye salmon *Oncorhynchus nerka* caught in the central Bering Sea in the summer of 2009 was estimated to evaluate migration patterns of salmon of Canadian origin, which have not been demonstrated previously to rear in the Bering Sea. The variation at 14 microsatellites was analyzed for 450 immature sockeye salmon, and a baseline of 387

populations from Japan, Russia, Alaska, Canada, and Washington State was used to determine the stock composition of the fish sampled. Sockeye salmon originating from Alaska were the most abundant in the catch, comprising 86.0% of all sockeye salmon caught, the catch being dominated by sockeye salmon of Bristol Bay origin. Russian-origin sockeye salmon accounted for 10.2% of the catch, while Canadian-origin sockeye salmon accounted for 3.8% of the catch. Salmon from Canada were estimated to originate from the Fraser River, Rivers Inlet (Owikeno Lake), the Skeena River (Babine Lake), the Stikine River, and the Alsek River, British Columbia. These results indicate that the central Bering Sea provides a summer rearing area for some Canadian sockeye salmon.

Garvin, M. R., K. Saitoh, D. Y. Churikov, V. A. Brykov, and A. J. Gharrett. 2010. Single nucleotide polymorphisms in chum salmon (*Oncorhynchus keta*) mitochondrial DNA derived from restriction site haplotype information. Genome 53 (7): 501-507.

Single nucleotide polymorphisms (SNPs) are useful genetic markers for the management and conservation of commercially important species such as salmon. Informative markers can be derived from data obtained for other purposes. We used restriction endonuclease data from earlier work to identify potentially useful restriction sites in chum salmon (*Oncorhynchus keta*). With the aid of a newly generated complete mitochondrial DNA sequence (accession number AP010773), we identified the SNP responsible for each restriction site variant, designed rapid genotyping assays, and surveyed the SNPs in more than 400 individuals. The restriction site analysis and the SNP genotyping assays were almost perfectly concordant. Some reasons for the non-concordance were identified and discussed.

Seeb, L. W., W. D. Templin, S. Sato, S. Abe, K. Warheit, J. Y. Park, and J. E. Seeb. 2011. Single nucleotide polymorphisms across a species' range: implications for conservation studies of Pacific salmon. Molecular Ecology Resources 11 (supplement 1): 195-217.

Studies of the oceanic and near-shore distributions of Pacific salmon, whose migrations typically span thousands of kilometres, have become increasingly valuable in the presence of climate change, increasing hatchery production and potentially high rates of bycatch in offshore fisheries. Genetics data offer considerable insights into both the migratory routes as well as the evolutionary histories of the species. However, these types of studies require extensive data sets from spawning populations originating from across the species' range. Single nucleotide polymorphisms (SNPs) have been particularly amenable for multinational applications because they are easily shared, require little interlaboratory standardization and can be assayed through increasingly efficient technologies. Here, we discuss the development of a data set for 114 populations of chum salmon through a collaboration among North American and Asian researchers, termed PacSNP. PacSNP is focused on developing the database and applying it to problems of international interest. A data set spanning the entire range of species provides a unique opportunity to examine patterns of variability, and we review issues associated with SNP development. We found evidence of ascertainment bias within the data set, variable linkage

relationships between SNPs associated with ancestral groupings and outlier loci with alleles associated with latitude.