

## Review of Studies on Asian Juvenile Pacific Salmon Stocks, 2006-2012

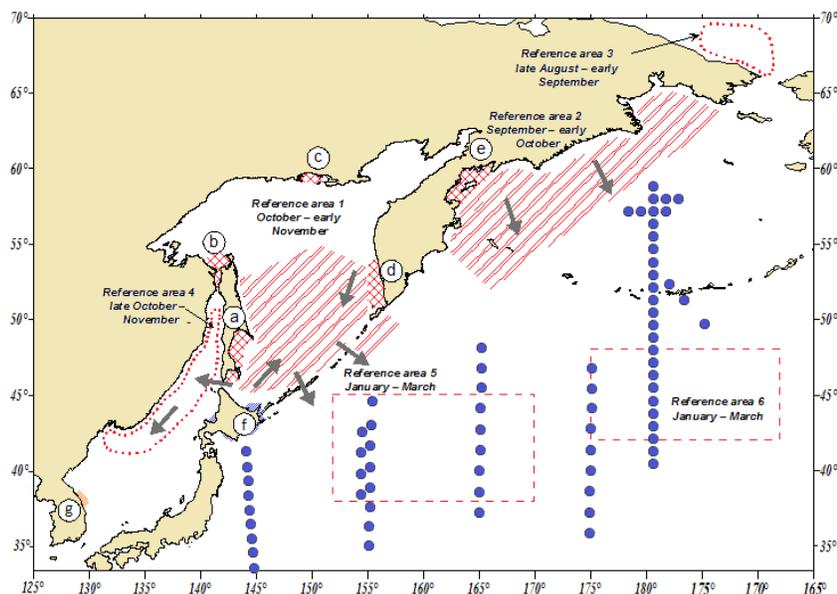
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Studies of Asian juvenile Pacific salmon stocks have been conducted by the national research programs of Korea, Japan, and Russia towards achieving the NPAFC Science Plan objectives (Fig. 1). They have primarily focused on salmon growth and survival rates under different hydrological conditions (water temperature, salinity, and circulation dynamics), spatial distribution and migration patterns, food supply, feeding habits and trophic relationships, and bioenergetic balance of fish. Estuarine and coastal studies have been investigated for the practical purpose of specifying optimal marine conditions for releasing salmon from hatcheries. In offshore waters, data were collected for studies of stock assessment and population dynamics based on stock identification.



**Fig. 1.** Reference regions for integrated surveys of estuarine-coastal and marine periods of life for juvenile salmon in the northwestern Pacific Ocean, 2006-2012 (compiled after Nagata et al. 2007; Fukuwaka et al. 2010; Shuntov 2010; Kasugai et al. 2012; Kim et al. 2013; Sasaki et al. 2013).

### Freshwater residence and downstream migration

Biological parameters and survival of juvenile salmon entering the marine environment depend on seasonal processes affected by inshore conditions at the time of freshwater residence and downstream migration. On Sakhalin and Iturup islands, gradual intensification of pink salmon downstream migration proceeds against a background of in-river water heating and water level lowering (Kaev et al. 2012). From 75% to 90% of the migrants leave three relatively short rivers in a two-week period. Migration rates change more gradually in larger streams. Four peaks of migration intensity occur in the Rybatskaya River (Iturup Island), where water conditions do not change so sharply. On the northern Sea of Okhotsk coast, juvenile salmon downstream migrations intensify with the seasonal rise of flood waters (Volobuev and Marchenko 2011). In-river water temperatures are 7-8°C at the time of migration peaks in early to mid-June. Migration duration is also longer in larger streams, where it lasts until mid-July. Juvenile chum salmon migrate from the Ol'ga and Avvakumovka rivers (southern Primorie) more intensively in mid-May with water temperatures of 8.8-14.9°C (Kolpakov et al. 2012). In conclusion, juvenile salmon downstream migration dynamics is notably affected by water temperature, level, and discharge rate, but this dependence is different by region and in small and large river basins. For methodological reasons, this variability requires expansion of reference river networks to encompass different types of spawning streams.

In the northern-most Asian regions, long-term exposure of salmon roe and larvae to cold waters during 5-7 months leads to worsening of progeny condition and increased mortality rates after entering the sea. The possibility of utilizing local watersheds for placing net pens for juvenile chum salmon growth to increase their viability has been considered (Khovanskaya et al. 2008, 2009). Ando et al. (2011) reported promising results in vertebral number variation in naturally spawning chum salmon as a response to incubation water temperature. A vertebral number index may be a useful parameter for estimating environmental conditions during ontogenesis.

During the course of the downstream migration, juvenile salmon food spectra usually expand and diet ration changes from nektobenthic crustacean and insect larvae to zooplankton (Kolpakov et al. 2012). Chironomid larvae and pupae were a preferable food for most salmon species in the Bolshaya River basin (western Kamchatka coast) in April-October 2012. For sockeye salmon, chironomids contributed 87.5-96.0% of total food consumed (Yarosh 2013). Salmon fry do not suffer a food deficit and feed and grow intensively.

In the Meiny-Pylgino River-Lake system (northwestern Bering Sea coast), the food spectrum of pink salmon was mostly composed of insects in July 2012. In the coastal zone adjacent to the river mouth, pink salmon mainly fed on capelin eggs and larvae, which contributed 68-90% of the total weight of stomach contents (Golub and Golub 2012). At this northern periphery for pink salmon spawning, abundance of migrants was the highest and duration of the out-migration was the longest for the whole period of observations conducted since the late 1990s. Food and hydrological conditions for the 2012 pink salmon year-class was favorable.

### **Coastal zone residence**

The first days in the coastal zone are usually considered a critical period of life for juvenile salmon (Beamish and Mahnken 2001). Survival depends on ambient water temperatures that determine metabolic rates of salmon fry and their prey and predators. Thermal conditions in the early marine period depend on downstream migration timing as was shown for wild masu salmon smolts from the Shokanbetsu River on the western coast of Hokkaido (Miyakoshi and Saitoh 2011). In northern areas, temperature shock can occur if juveniles enter the sea at notably lower marine water temperatures in comparison with river thermal conditions. In southern waters around Hokkaido, colder waters usually support a more favorable food supply for juveniles that are represented by high-calorie copepods of the boreal faunistic complex (Seki et al. 2006; Asami et al. 2007; Saito et al. 2009). The optimal sea water temperature (SST) varied between 7-11°C for juvenile salmon out-migrating into coastal Hokkaido waters (Miyakoshi et al. 2007; Nagata et al. 2007). In the coastal zones of Sakhalin and Iturup islands, optimal SST for juvenile chum release was assessed at 6-7°C (Shershneva et al. 2007). On the western Kamchatka shelf, maximal trawl catches of juvenile salmon occurred at 8-9°C in mid-July and 10-13°C in late July – early August (Kolomeitsev 2009; Koval et al. 2011).

In Nemuro Bay (eastern Hokkaido), marked chum salmon were released and re-captured by nets and trawls in the littoral zone and inshore waters between late April and mid-July (Kasugai et al. 2012). As it was found, environmental variability in coastal areas might influence growth of marked fish released in mid-April more strongly than those released after mid-April. Delayed migration to inshore areas from the river or littoral zone due to low SSTs may result in high mortality. It was recommended to reduce releases of juvenile chum salmon into Nemuro Bay by late April–mid May. Size at release of chum salmon from hatcheries, early marine growth of juveniles, and adult returns for five Hokkaido stocks were investigated in relation to SST using path analyses (Saito et al. 2011). Direct linkage between size at release and return rates was found in three stocks—Ishikari, Shari, and Nishibetsu. Results confirmed that juvenile salmon mortality occurred in two phases, including during coastal residency, and the relative importance of both phases varied by stock, region, and downstream migration timing.

Correlations between estimated juvenile sockeye salmon abundance during the downstream migration and assessment by pelagic trawl surveys in the 12-mile coastal zone along the western Kamchatka coast were found in 2005-2011 (Koval and Kolomeitsev 2011). Juvenile sockeye salmon initially migrated northwards in the eastern Sea of Okhotsk like pink and chum salmon in the main spawning regions of the Russian Far East and like chum salmon in the coastal waters of the Korean Peninsula (Kim et al. 2013). Maximal sockeye salmon juvenile catches were 409 fish per 15-min haul northward from the mouth of the Ozernaya River.

Large numbers of juvenile salmon leave the coastal zone for offshore waters when SSTs are above 13°-15°C (Radchenko et al. 2007; Koval et al. 2010; Miyakoshi and Saitoh 2011). These observations agree with experimental results of juvenile sockeye salmon swimming performance that notably declines at temperatures above the optimum 15°C (Brett 1971). The optimum temperature for juvenile salmon changes during the marine phase of the life cycle, and the whole range of thermal conditions in salmon marine habitat significantly exceeds optimal temperature values (Shuntov and Temnykh 2008).

Water mass dynamics, ice conditions in the previous winter, and salinity are listed among the main hydrological factors effecting forage zooplankton abundance and species composition in the coastal zone of the Kamchatka Peninsula (Morozova 2013). Juvenile salmon growth and survival are also affected by feeding interactions with other fish species. Abundant herring in the common feeding areas with juvenile salmon can also serve as a factor to start the migration of salmon juveniles

from the inshore zone near the mouth of the Kamchatka River (Koval et al. 2010). Phytoplankton blooms also begin to develop in the well-heated inshore zone, and juvenile salmon migrations can be temporally related to this seasonal event. Potentially toxic algae species *Alexandrium tamarense complex* present along the western Kamchatka coast (Lepskaya et al. 2009) may prompt juvenile salmon to start migrating further offshore.

An impressive observation of pink salmon intraspecific relations was made in the northern Sea of Okhotsk coastal zone. In the Taui Inlet, which has one of the earliest pink salmon adult returns in the Sea of Okhotsk basin, two adult pink salmon were observed to have consumed pink salmon fingerlings in mid-June 2008 (Izergin et al. 2008). However, this form of intraspecific competition is not likely a significant factor affecting pink salmon populations. In most spawning regions, the overlap in timing of adult pink salmon returns and downstream migration of juveniles is not typical, and rapid early growth of juveniles rather quickly puts them beyond the optimal prey size for adult salmon.

### Deep sea residence

Juvenile salmon surveys in the offshore area of the Sea of Okhotsk have been conducted annually. Juvenile pink salmon were widely distributed through the deep sea zone in 2009-2012, so the trawl survey area was expanded in the last two years to 750,000-900,000 from 260,000-400,000 km<sup>2</sup>. In autumn 2011, juvenile salmon abundance was estimated at 950 million fish with mean body weight at 101 g, and 262,000 metric tons of pink salmon were harvested in the Sea of Okhotsk basin in 2012. In autumn 2012, pink salmon juvenile abundance was assessed at 1.128 billion fish. Mean weight was almost 2-times higher—188 g—than in 2011. These assessments imply an even higher catch level in the coming salmon fishery season there in 2013. In 2011 and 2012, juvenile pink salmon aggregations occurred northward of 47°-48° N. In the previous three years, pink salmon occurred across the whole deep-sea basin in the southern Sea of Okhotsk, and in 2010 aggregations even partially extended into in the Pacific Ocean. It was concluded that a slow growth rate was related to slower migration velocity from the shelf zone to open waters of the Sea of Okhotsk and then to the Pacific Ocean. However, it must be taken into account that juvenile pink salmon from the northern Sea of Okhotsk usually have smaller average size and leave for the Pacific Ocean earlier than other populations.

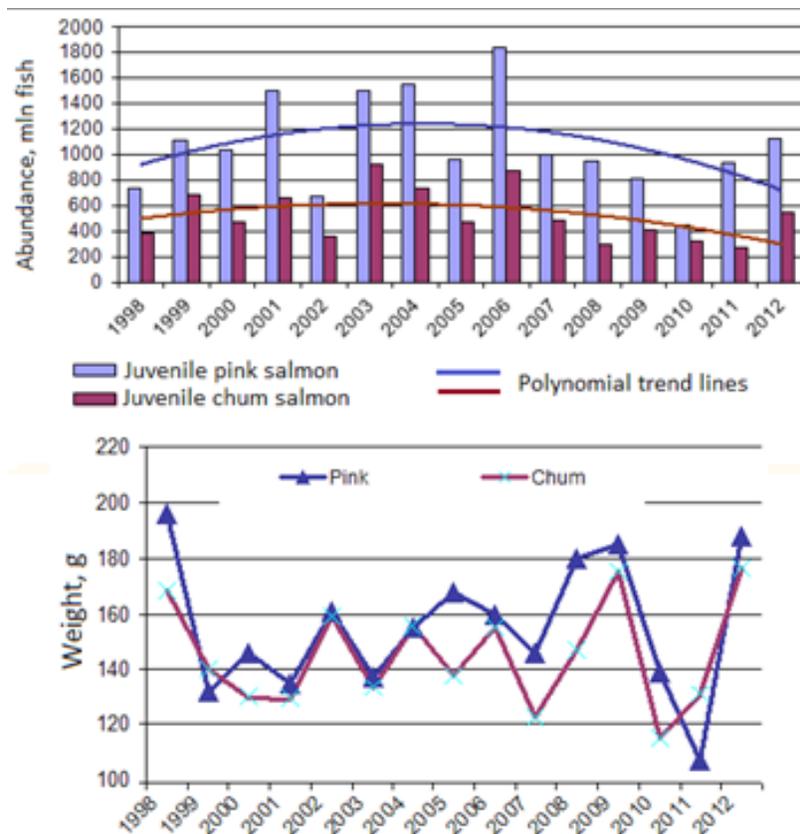
In 2012 juvenile chum salmon abundance attained the highest level observed since the previous six years—550 million fish. Since 2005 chum salmon approaching the Russian far-eastern coasts have followed the general trend of increasing stock abundance. Older immature chum salmon have expanded their feeding area and residence time in the Sea of Okhotsk. In autumn 2012, their biomass increased to 100,000 metric tons.

Interspecific relationships of salmon sharing the same feeding area are often considered as an additional factor effecting survival and growth. Researchers have hypothesized that pink salmon in years of high abundance can exhaust the food supply and lead to enhanced mortality of chum and sockeye salmon, which compete for the same zooplankton resources (Kaga et al. 2013). Our 15 years of surveys do not support the idea that a similar situation occurs universally throughout the North Pacific Ocean. For example, in autumn in the Sea of Okhotsk, juvenile pink and chum salmon behave as complementary species with similar patterns of abundance dynamics and body weight (Fig. 2).

Spatial, seasonal, and daily changes in zooplankton communities affect juvenile salmon feeding. As a rule, the copepod portion of the diet decreases and the portion of amphipods, euphausiids, fish egg and larvae increases as the juvenile salmon move seaward (Koval et al. 2007; Nagata et al. 2007; Morozova 2010). The relation between the daily rhythm of juvenile salmon feeding intensity and zooplankton vertical migrations has been investigated (Karpenko and Koval 2007; Koval 2007). Correspondingly, the general pattern of feeding intensity is similar for the planktivorous salmon species (Volkov and Kosenok 2007). The daily food ration and energetic expenditure for growth decrease for all salmon species from summer to late autumn (Karpenko et al. 2007; Erokhin and Shershneva 2007). This reduction is related to the seasonal lowering of feeding intensity and growth that is an adaptation to lower ambient temperatures and less favorable food supplies in winter. Among salmon species, pink salmon have the highest rate of food consumption (relative to body weight) and gross growth efficiency compared to other salmon species (Erokhin and Shershneva 2007). Distinctions in behavioral and biochemical adaptations were found among juvenile pink, chum, and sockeye salmon in the Okhotsk Sea (Klimov et al. 2013).

Monitoring juvenile salmon in the Russian far-eastern seas is conducted from the viewpoint of the ecosystem (Shuntov and Temnykh 2008). This means the structure and dynamics of nektonic communities, place and role of salmon in the ecosystem, their food supply and feeding habits, trophic relationships and degree of potential competition for food with other pelagic animals, and predation pressure are investigated.

Increasing juvenile salmon stock abundance has been followed by increased total nekton biomass in the upper epipelagic layer of the Sea of Okhotsk. The percentage of salmon within the total pelagic fish and squid biomass in the southern Sea of Okhotsk decreased to below 39% on average. These significant changes have occurred in nekton community composition due to the increase in biomass of mesopelagic fish, which undertake diurnal vertical migrations. The portion of the composition comprising mesopelagic fish increased to almost twice, in comparison with the previous eight-year period, and attained 29% of total nekton biomass.



**Fig. 2.** Abundance dynamics of juvenile pink and chum salmon (upper panel) and interannual changes in body weights (lower panel) in the Sea of Okhotsk in autumn, 1998-2012.

During the last seven years, significant changes also occurred in the composition and structure of epipelagic nektonic communities in the western Bering Sea. The average total nekton biomass decreased by half in autumn 2006-2012 in comparison with the previous four years due to a reduction in walleye pollock abundance. The salmon component in the epipelagic nektonic community increased to 43%, even when the absolute value of salmon biomass slightly decreased. The juvenile pink salmon portion of total nekton biomass increased in even years. Exceptionally high yields of juvenile pink salmon year-classes entered the western Bering Sea in 2008 and 2010 (Glebov et al. 2008; Temnykh 2009; Shuntov and Temnykh 2011). The total number of pink salmon outmigrants from eastern Kamchatka exceeded 1.0 billion fish and were on the same level as the Sea of Okhotsk stocks. Despite relatively low mean weight in 2008, these year-classes have ensured the all-time maximum pink salmon harvest on the eastern Kamchatka coast: first in 2009 and then again in 2011. Pink salmon daily food ration was positively correlated with the abundance of preferred prey, which is similar to the conditions in the Sea of Okhotsk.

Changes in total salmon biomass in the western Bering Sea were related to decreases in stock abundance of immature chum and sockeye salmon. They were less abundant there in 2006-2011 in comparison with previous years of the BASIS program. Along the eastern Bering Sea coast, gradual decreases in juvenile salmon abundance also occurred since 2006 (Farley 2010). This suggests there was shrinkage of the feeding migration area. Immature chum and sockeye salmon abundance indices increased again in 2012, but the future trend remains unclear because the number of out-migrants in the western Bering Sea was low.

These fluctuations occurred against a background of surface water cooling in the Bering Sea, especially in the eastern area, which has continued to the present time (Khen et al. 2013). Periods of warm and cold temperature regimes were relatively short in 1980-2000: not longer than three years. The recent warm period in 2001-2006, and the cold period in 2007 to the present time have been longer and more strongly expressed. We are expecting a stronger effect on planktonic and nektonic communities. The immature ratio-at-age of chum salmon in the Bering Sea has increased (Watanabe et al. 2013), and the average body weight of chum salmon is lower in the central Bering Sea in 2011 as compared to 2007-2009 (Morita et al. 2011). This can also be related to lower ambient water temperature in salmon habitats.

Climate-oceanographic changes in the far-eastern seas are accompanied by clear changes in the quantitative composition of planktonic communities that are the food supply of salmon. Regional features of multiyear zooplankton dynamics were revealed by integrated surveys conducted by researchers aboard Russian, American, and Japanese research vessels (Volkov et al. 2007; Shuntov and Temnykh 2008; Volkov 2008a, b; Shuntov et al. 2010; Shuntov and Temnykh 2011; Volkov 2012a, b, c). Variability in zooplankton composition excites corresponding changes in the diets of nekton, including juvenile salmon. In the western Bering Sea, salmon food spectra varied slightly. Three main prey components—amphipods, euphausiids, and pteropods—have contributed from 78% to 96% of food consumed by juvenile salmon. The portions of these prey varied 5-10% in smaller (15-20 cm) and larger (20-30 cm) size salmon. In the eastern Bering Sea, composition of juvenile salmon diets varied sharply from year to year. Fish larvae and fry formed the basis of prey composition in 2003-2005, and euphausiids and amphipods were the predominant food components in 2006-2007. Since 2008, the hyperiid amphipod, *Themisto libellula*, occurred more abundantly in the ration of planktivorous salmon. Well-expressed changes in the diet of juvenile salmon can strongly affect stock conditions. The western Bering Sea may offer more stable forage conditions, which seems to be more favorable for salmon feeding.

Creation of the TINRO-Center zooplankton database allows for analysis of forage plankton distribution and abundance throughout the far-eastern seas and adjacent waters in all seasons. Large zooplankton standing crop is mainly aggregated in the deepwater basins, while higher biomass of small and middle-sized planktonic animals is observed on the shelf and continental slope zones. Total zooplankton abundance slightly differs in the northwestern and northeastern Pacific. Four taxonomic groups usually predominate in subarctic zooplankton, but only two—euphausiids and amphipods—can be defined as preferred salmon food components in areas beyond coastal waters. Considering the distribution of euphausiids and amphipods, it has been hypothesized that salmon food supply is more plentiful and forage conditions more favorable in the western part of the subarctic North Pacific, especially in Russian waters. In this area, the food supply is supplemented by pteropods and appendicularians, which are readily consumed by planktivorous salmon.

Despite well-expressed seasonal variability, zooplankton resources in the open North Pacific Ocean are sufficient to ensure the food requirements of salmon (Shuntov and Temnykh 2011). There is a seasonal decline, but zooplankton biomass does not decrease sharply in winter. In the northwestern Pacific Ocean zooplankton biomass in winter remains relatively high—averaging more than 300 mg/m<sup>3</sup>. Our estimates of zooplankton biomass in the open North Pacific are an order of magnitude higher than those published by Nagasawa (2000). According to our calculations, zooplankton biomass does not fall below a critical level that would contribute to salmon natural mortality due to insufficient food. In addition to zooplankton, the biomass of small-size nekton is an additional component of the food supply for salmon, and it is several times higher in the open waters of the North Pacific Ocean than in the deep-water regions of the Okhotsk and Bering seas.

Multiyear dynamics of average zooplankton abundance in the upper epipelagic layer displayed contrary trends in the far-eastern seas and northwestern Pacific Ocean. There were maximal abundances of juvenile salmon in the northwestern Pacific Ocean in 2009-2012 despite a significant decrease in zooplankton abundance in the open areas in the Sea of Okhotsk. Comparison of juvenile salmon food spectra with composition of planktonic communities demonstrated well-expressed salmon prey selectivity (Naydenko et al. 2007; Volkov et al. 2007; Zavolokin et al. 2007; Naydenko et al. 2008; Shuntov and Temnykh, 2008; Shuntov et al. 2010; Zavolokin 2011). Salmon prey selectivity supports the existence of a significant reserve of secondary food that enables salmon to mitigate trophic competition in times of preferred prey shortages.

Chiba et al. (2012) examined the long-term change in the trophic link between *Neocalanus* copepods and pink salmon in the western subarctic North Pacific based on nitrogen stable isotope ( $\delta^{15}\text{N}$ ) analysis. They observed that *Neocalanus* biomass and pink salmon catch increased in the 1990s and related these increases to pelagic food web dynamics. It was hypothesized that *Neocalanus* production/survival benefited from favorable food conditions rich in phytoplankton, which secondarily enhanced pink salmon production. Our data on juvenile salmon feeding do not support the idea that large copepods hold particular significance for salmon nutrition. However, Chiba et al. (2012) undoubtedly emphasized a tight connectivity in the trophic structure of subarctic pelagic ecosystems.

Estimations of zooplankton consumption by salmon in comparison with other nektonic species show that consumption is modest, even in years of high salmon abundance (Naydenko et al. 2007, 2008; Shuntov and Temnykh 2008; Shuntov et al. 2010). In the warm season, total zooplankton consumption by common nekton species does not exceed 15% of prey biomass. For the whole year, zooplankton consumption by nekton ranges from 3% to 20% and varies significantly among the northwestern Pacific regions. Juvenile salmon consumed no more than 1-2% of the total large zooplankton biomass. In the western Bering Sea salmon prey consumption does not exceed 8% of the total food consumed by nekton. In the southern Sea of Okhotsk, juvenile salmon can eat 50-60% of the total consumed by epipelagic nekton.

Data from juvenile pink salmon autumn surveys are used to improve annual adult run forecasts. The forecast is usually generated in two steps: estimation of overall abundance of juvenile salmon in offshore waters of the Okhotsk and Bering seas and regional stock-group identification of the mixed marine aggregations. The stock identification analyses are based upon scale pattern, otolith analysis, and genetic methods. Baseline information of otolith microstructure phenotypes of pink and

chum salmon have been obtained from regions of the Okhotsk Sea, including West Kamchatka, Sakhalin, and the northern coast (Chistyakova et al. 2013). Otoliths were collected in the Sea of Okhotsk northward of 49°N in October-November of 2011. About 72% of total juvenile pink salmon and more than 75% of juvenile chum salmon abundance are represented in the baseline by western Kamchatka wild stocks. Genetic methods of identification referred 54.4% of juvenile pink salmon to the “northern populations”, which was close to the 57% identified in the total pink salmon harvest the following year (Shevlyakov et al. 2012). Among juveniles released from hatcheries, pink salmon from the Kuril’sky hatchery (60%) and chum salmon from Japanese hatcheries (71%) have predominated. More detailed information on otolith marking and genetic stock identification is presented in several extended abstracts in this volume (Saito et al. 2013; Sasaki et al. 2013; Sato et al. 2013; Yoon et al. 2013).

Survival rates of the parental generation must be taken into account when analyzing abundance indices of juvenile salmon. Marine survival of pink salmon from Sea of Okhotsk populations decreased in the first decade of the current century and then began to stabilize (Radchenko 2012). However, marine survival did not attain the values observed for less abundant year-classes of the 1990s. Therefore, we are expecting adult pink salmon returns to the Sea of Okhotsk of about 25% of estimated out-migrant abundance, or 282 million fish. This forecast will be updated after the pelagic trawl surveys of maturing salmon in the ocean waters off eastern Kamchatka and the Kuril Islands in June-July of this year, one month before the fishery begins.

Deviations in the pink salmon catch on the Russian coast (1956-2012) varied similarly to the annual world ocean heat content for the 0-700 meter depth layer (Levitus et al. 2005, with additions from [http://www.nodc.noaa.gov/OC5/3M\\_HEAT\\_CONTENT/](http://www.nodc.noaa.gov/OC5/3M_HEAT_CONTENT/)). The relation between catch dynamics and general ocean heat content is stable and remains significant since 2005, when this relationship was first observed. Ocean heat content is determined by climate and synoptic conditions in previous years. It is also correlated with the short-term data series on zooplankton biomass in the upper epipelagic layer of the northwestern Pacific, i.e., throughout the region, which keeps more heat in the upper layer than adjacent layers.

There has been promising parasitological and ichthyopathological studies conducted on different salmon stocks in Korea and Japan (Setyobudi et al. 2010; Suebsing et al. 2011; Urawa 2013). In Russia, advanced ichthyopathological salmon studies are conducted at research institutes in Kamchatka and Sakhalin. They focus on problems of viral and fungal diseases, sea lice outbreaks, and monitoring of hatchery and wild stocks (Vyalova and Shkurina 2005; Rudakova 2008).

## Conclusions

1. Most research conducted in 2006-2012 proved the importance of juvenile salmon body size for survival in early marine life. Nevertheless, notable variability of adult salmon return rates despite a stable weight of released juveniles supposes the existence of other important factors driving salmon survival. Thermal conditions, timing of juvenile release, and growth rates are listed among such significant factors for salmon survival. The significance of these factors varies by region and life stage of salmon.
2. Analysis of abundance dynamics indicates that oceanographic and feeding conditions throughout Asian juvenile salmon habitats during the first marine summer and autumn are generally favorable for salmon. A tendency for acceleration of first marine year growth was observed for many Asian chum salmon stocks. Favorable feeding conditions likely play the most important factor during the coastal residence of salmon juveniles, and the thermal regime is the most important factor during the offshore residence period.
3. Studies of trophic relationships and potential competition for food in pelagic nekton communities have provided the understanding that carrying capacity of marine and ocean ecosystems can support the current high level of salmon abundance. The relatively low significance of salmon prey consumption compared to total zooplankton resources suggests good prospects for further hatchery program development in the western North Pacific, at least before there is a new wave of Japanese sardine production.
4. Juvenile pink and chum salmon abundance monitoring in the open sea waters provides a useful tool for predicting the magnitude of adult salmon returns to fisheries.
5. Results from studies on the early marine life period of salmon emphasize the necessity to expand salmon research programs on their status, and their physical and biological surroundings in subsequent life periods, especially during the winter in the North Pacific Ocean. Based on freshwater and coastal studies using varied approaches and the voluminous efforts by NPAFC-member countries, there has been clear progress in understanding salmon stock dynamics. If we work together on research related to the offshore life period of salmon at the same level of cooperation, we can expect the same high degree of advancement in our knowledge of ocean salmon.

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