Predation by Lamprey Smolts *Lampetra japonica* as a Main Cause of Amur Chum Salmon and Pink Salmon Mortality in the Early Sea Period of Life

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Investigations conducted between 1986-1993 using smolt trawls in the Amur Estuary and the adjacent sea area revealed that lamprey smolts preyed upon chum and pink salmon smolts. It was determined that 15% to 25% of lamprey smolts had the remains of salmon in their intestine. It was also determined that 2% to 31% of live salmon smolts collected showed signs of lamprey wounds. It was estimated that Lamprey consumed approximately 75% of the pink and chum salmon smolts migrating through the Amur Estuary.

The early sea period of life of pink and chum salmon in the Amur estuary and in the adjacent sea area was investigated between 1986 and 1993. It was observed that the sea migration of lamprey smolts occurred at the same time as the migration of salmon smolts (Fig. 1). Migration patterns of lamprey and salmon smolts in the Amur Estuary and in the adjacent sea area are similar (Fig. 2).

Most of salmon and lamprey traverse the Amur Estuary very quickly (approximately one day) and appear in the Sakhalin Bay. A smaller portion stays within the shoal waters of the southern portion of the Estuary for one to one and a half months. Very few of these smolts are from the Amur River; the majority of the smolts in the shoal waters are from local streams. The salmon smolts can grow up to 8.5 cm and the lamprey up to 21 cm during this period. Early migrating (until June) salmon smolts from streams in the southern portion of the Amur Estuary move directly into the Japanese sea (through the Nevelskoy Strait). The salmon that originate in the Amur River do not migrate southward. In July, a current appears periodically that carries salmon and lamprey smolts that have accumulated in the southern portion of the Amur Estuary northward into the Sakhalin Bay. It was discovered that the migrating lamprey smolts prey upon the smolts of chum and pink salmon. Wounds containing suction and lateral tooth marks were discovered on some of the recovered salmon smolts. These wounds are characteristic features of lamprey bites (Fig. 3).

No chum or pink salmon (size 33-88 mm) whose wounds had healed appeared in the catches. Only cherry salmon *Onchorhynchus masu* with lengths of 12 cm or greater were caught with healed lamprey wounds.

In the large catches the number of salmon recovered with lamprey injuries greatly exceeded the number of lamprey recovered. In the sampled catches 15% to 25% of lamprey had remains of salmon smolts in their intestines.

The lampreys initiated their attacks on salmon within the fresh waters of the Amur Estuary (2% to 5% of salmon showed injuries in fresh water). The lamprey predation increased drastically in the brackish waters of the Amur Estuary and the Sakhalin Bay (17% to 31% of salmon recovered in these areas showed Lamprey wounds). Theoretically, this high rate of predation would reduce the abundance of salmon in these spatial-temporal aggregations to a very low number of individuals (Table 1). Lampreys appeared frequently in catches containing large numbers of salmon smolts. However, lampreys were absent in catches containing low numbers of salmon smolts.

From 37% to 68% of the salmon smolts in the various spatial-temporal aggregations were preyed upon by lampreys. Due to the similarities in the migration patterns of the lampreys and the salmon, the major portion of pink and chum salmon mortalities was attributable to lampreys. During the years of study, 75% to 93% of the mortalities of chum salmon passing through the Amur Estuary were attributable to lampreys and from 73% to 96% of pink salmon

Fig. 1. Dynamic of Amur salmon and lamprey migration in the Amur Estuary (average long-term data).

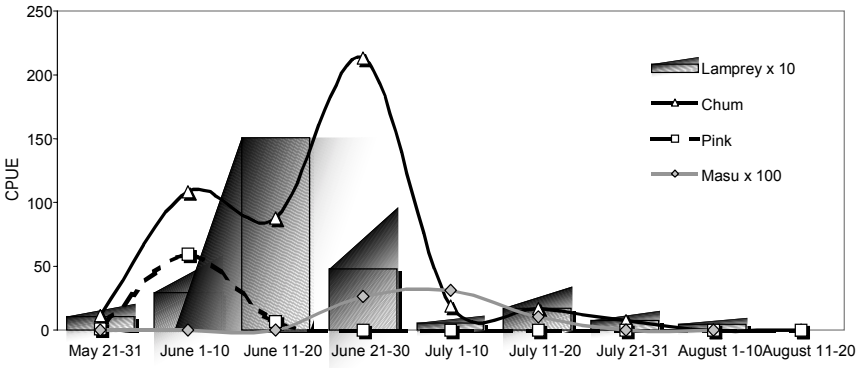

Fig.2. Generalized schema of salmon smolts and lamprey migrations in the Amur Estuary and in the adjacent sea areas.

Fig.3. Chum and pink salmon smolts wounded by lamprey from trawl catches in the Amur Estuary and the Sakhalin Bay.

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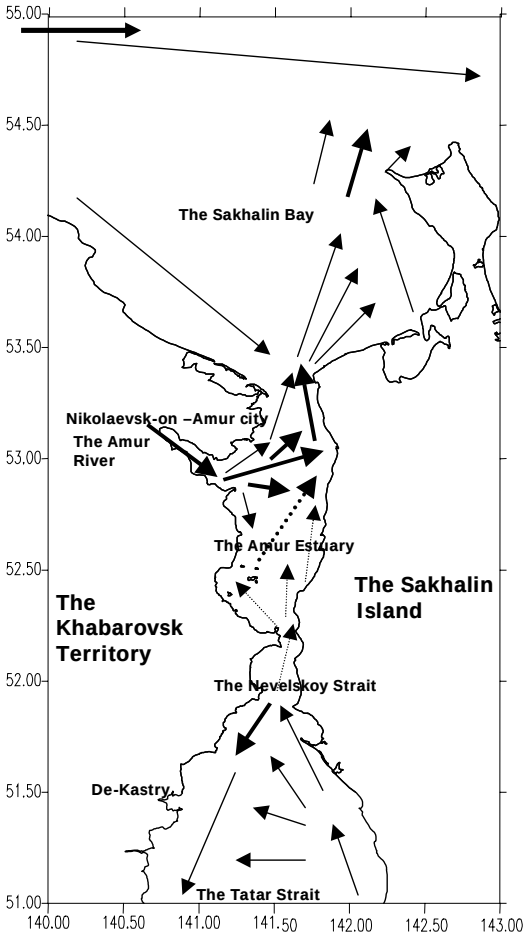

constant main concentrations of salmon

constant low concentration of salmon

periodically occurred migrations, caused of current from the Tatar Strait to the Sakhalin Bay through the Amur Estuary (main concentration)

periodically occurred migrations (low concentration)

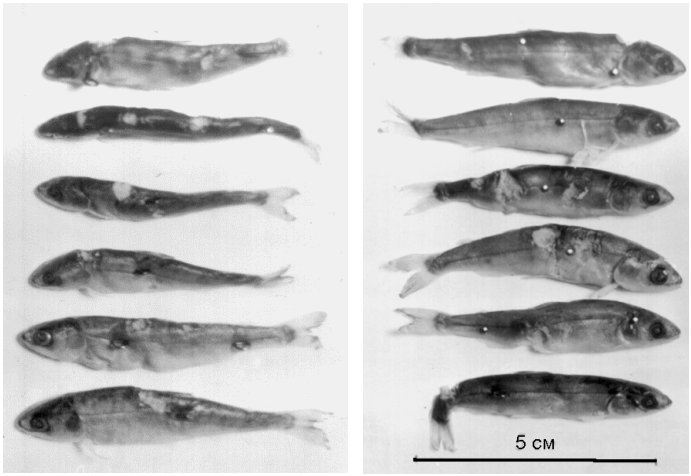

Table 1. Correlation of salmon smolts abundance and predators in fairway of the Amur Estuary.

Species	Portion in the catch, %
Chum salmon	64.04
Pink salmon	21.48
Lamprey	12.85
Arctic smelt	1.58
Ussuri whitefish	0.05

mortalities were attributable to lampreys. Predation by arctic smelts *Osmerus mordax dentex* and Ussuri whitefish *Coregonus ussuriensis* was considered a non-significant source of salmon mortality (maximum 0.04% to 0.15%), because these are not major predators in the Amur Estuary. However, these species consume a large number of salmon smolts in the estuary area of local streams.

One factor that accounts for decreased predation on salmon is a large biomass of smelt fry and *Neomysis sp.* Nearly all fish species present in the Amur Estuary prey upon these species during periods when their biomass peaks. In the saltwater areas of the Sakhalin Bay, trawl catches consisted only of salmon and lamprey. No other species were present.

Thus, for salmon smolt that migrate through the Amur Estuary, lampreys account for approximately 75% of all salmon smolt mortalities. They are by far the major source of salmon smolt mortality in this area during the early sea period of life.