Identification of Local Stocks of Sockeye Salmon (*Oncorhynchus nerka*) by Scale Pattern Analysis in the Russian Economic Zone

Alexander V. Bugaev
Kamchatka Research Institute of Fisheries and Oceanography (KamchatNIRO),
18, Naberezhnaya Str., Petropavlovsk-Kamchatsky, 683602, Russia

Keywords: Sockeye salmon, identification, scale pattern analysis, scale baselines, age groups, dynamic abundance, economic zone of Russia

Identification of local stocks of sockeye salmon in the Russian economic zone were made on the basis of scales collected in 1995-2001. Samples of sockeye salmon from different local stocks of Asia and North America of age groups 1.3 and 2.3 were used for the formation of the scale baseline. These age groups of adult sockeye salmon are dominant in the coastal and driftnet catches in the Asian region. The baseline consisted of 8,653 fish: (Eastern Kamchatka – 3,675 , Western Kamchatka – 3,294,, Kommander Islands – 250, Kuril Islands – 34, and Bristol Bay (Port Moller) – 1,400 fish) (Fig. 1).

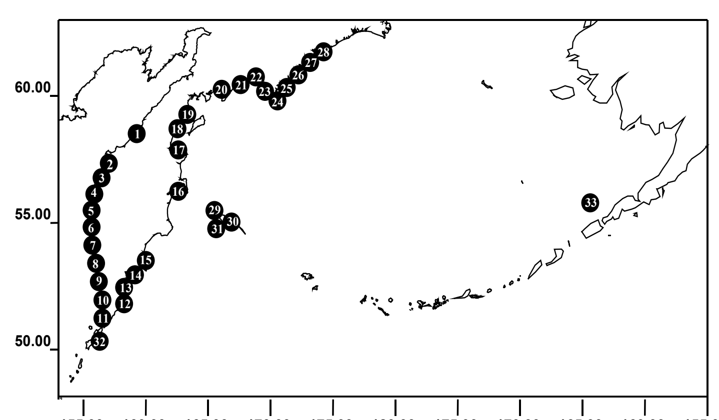
Scales were taken from sockeye salmon that were collected from driftnet catches in the southwestern part of Bering Sea (Karaginskaya subzone – 61.02.1) and adjacent waters of the northwestern part of Pacific Ocean (Petropavlovsk-Kommander subzone – 61.02.2 and Pacific subzone – 61.03.1). The total sample size consisted of scales from 17,975 fish (61.02.1 – 5216 fish, 61.02.2 – 7630 fish, 61.03.1 – 5129 fish) (Fig. 2). Only mature sockeye salmon (about 90% from the total driftnet catches in economic zone of Russia) were included in analysis.

Scale pattern analysis was based on standard methods used by NPAFC (Davis et al. 1990). Analyses of the scale structure included measurements of the radius of the total freshwater zone and size of the first ocean annual zone (Fig. 3). The numbers of circuli and inter-circuli distances were measured in the first ocean zone. Fifteen scale criteria were used for identification of local stocks of sockeye salmon.

Results of the cluster analysis showed that significant differences were observed only between the stock complexes from Eastern Kamchatka - Western Kamchatka and Bristol Bay – Western Kamchatka. The stocks from Eastern Kamchatka and Bristol Bay formed a cluster using the scale baseline among age groups 1.3 and 2.3 in all cases. The most similarities in scale structure were observed between stocks from Northeastern Kamchatka (Navarinsky Bay and Olutorsky Bay) and Bristol Bay. Analogous results were found using the nonparametric Wilcoxon test that demonstrated a reliable difference ($p < 0.01$–0.05) only between designated stock complexes. This could be the result of similar environments for freshwater and early marine life history.

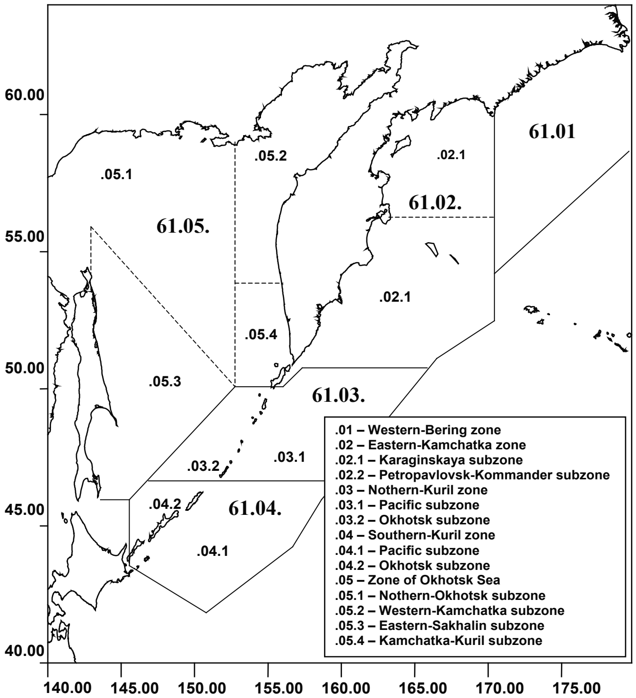
Thus, reliable identification by scale pattern analysis for complexes of sockeye salmon stocks from Eastern Kamchatka and Bristol Bay is impossible. Additional biological conditions will have to be used in this situation. For example, the dynamics of stock abundance or known tendency of distribution of major complexes of local stocks may be useful. We have to take into consideration other factors in our actual situation. Considering the time of the active commercial driftnet fishery and mass pre-spawning migrations of Asian and American origin sockeye salmon in Russian economic zone (June–July), and the geographic distances between continents (more than 2,000 km), it is logical to assume that the total catch of mature sockeye salmon in the Russian economic zone is predominantly of Asia origin.

Fig. 1. Map of the areas of scale collected for identification of local stocks of sockeye salmon in the Russian economic zone in 1995–2001: 1 – r. Palana; 2 – r. Icha; 3 – r. Oblukovina; 4 – r. Krutogorova; 5 – r. Vorovskaya; 6 – r. Kikhchik; 7 - r. Utka; 8 – r. Bolshaya; 9 – r. Opala; 10 – r. Ozernaya; 11 – r. Kambalnaya; 12 – r. Listvenichnaya; 13 – r. Paratunka; 14 – r. Avacha; 15 – r. Jupanova; 16 – r. Kamchatka; 17 – r. Khailulya; 18 – r. Rusakova; 19 – r. Dranka; 20 – r. Kultushnaya; 21 – r. Pakhacha; 22 – r. Impuka; 23 – r. Apuka; 24 – r. Anana; 25 – r. Severnaya; 26 – r. Tamanvayam; 27 – r. Machevna; 28 – r. Ilpiveem; 29 – r. Sarannaya; 30 – r. Gavanka; 31 – r. Ladyginka; 32 – r. Bettobu; 33 – Port Moller (Bristol Bay).



All correspondence should be addressed to A. Bugaev.
e-mail: Bugaev2@kamniro.ru

Fig. 2. Map of the fisheries areas within the far eastern part of the Russian economic zone (region 61.)



Therefore, the scale baseline is only useful for the identification of Western and Eastern Kamchatka stocks of sockeye salmon which account for more than 95% of the total Asian stocks. Stock identification error is not appreciable in this case. Note that in this situation, it does not pertain to immature fish. The mean accuracy for homogenous-mixture baseline-dependent simulation results for the cluster-based analysis are about 92–98%.

Results of the stock identification analyses of mature sockeye salmon in the driftnet catches are based on the maximum likelihood estimate (Millar 1987, 1988, 1990). Specific distribution of local stocks of sockeye salmon in the spring-summer period was determined for each fishery area. Stocks of Eastern Kamchatka were dominate in the southwestern part of the Bering Sea (Karaginskaya subzone – 61.02.1) in May–July at 86% (77–93%) (Fig. 4). The average fluctuations in the intensity of the run were about 1–3 fish / tan. The peak run of sockeye salmon was observed in the Karaginskaya subzone in mid-June. The proportions of Eastern and Western Kamchatka stocks were approximately equal (1: 1) in the northwestern part of the Pacific Ocean (Petropavlovsk-Kommander subzone – 61.02.2) (Fig. 5). These complexes of local stocks are maximally mixed in this subzone. In May and June the stocks of Eastern Kamchatka are dominate at 71% (48–85%) and 54% (39–68%), respectively. The peak run is observed in June–July at about 3–5 fish / tan. In July and August the percentage of Western Kamchatka stocks were above 77% (61–88%) and 88% (81–98%) respectively. The percentage of the Western Kamchatka stocks was still increasing reaching approximately 83% (66–94%) in the June–July period in the waters of Kuril Islands (Pacific subzone – 61.03.1) (Fig. 6). A large run is

Fig. 3. Image of a scale and the criteria used for identification of local stocks of sockeye salmon in the Russian economic zone: FW – total distance in the freshwater growth zone; O1 – total distance in the first annual ocean growth zone; tr1-tr6 – triplets circulus distance from first circuli in the first annual ocean growth zone (sixth triplets); rtr1-rtr6 – revers-triplets circulus distance from last circuli in the first annual ocean growth zone (sixth revers-triplets).

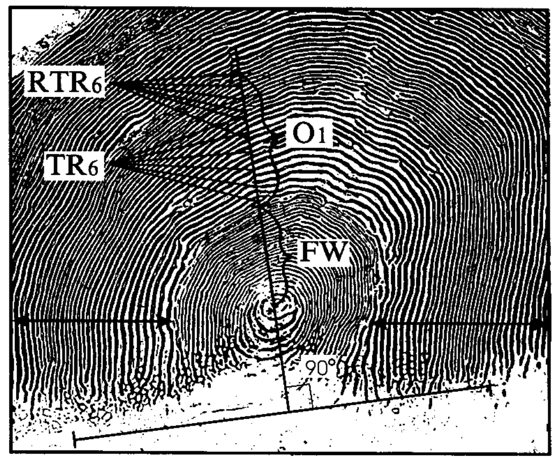


Fig. 4. Frequency dynamics of complexes of local stocks of mature sockeye salmon by main age groups from driftnet catches in the Karaginskaya subzone – 61.02.1

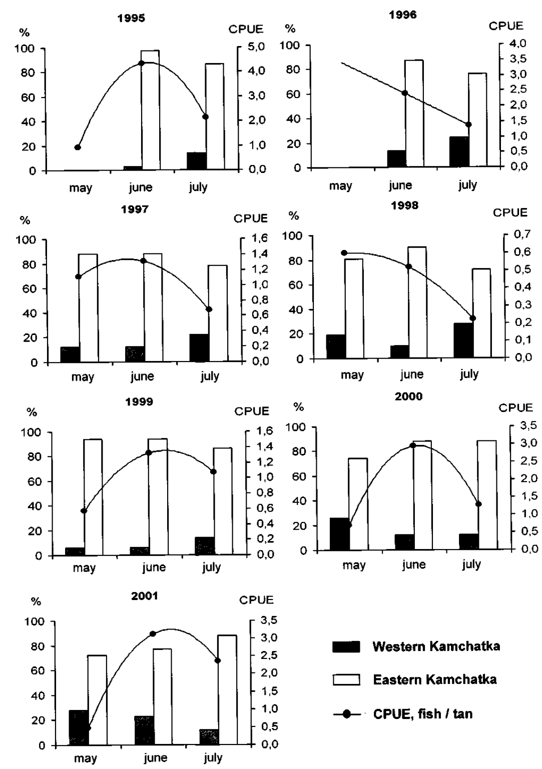


Fig. 5. Frequency dynamics of complexes of local stocks of mature sockeye salmon by main age groups from driftnet catches in the Petropavlovsk-Kommander subzone – 61.02.2

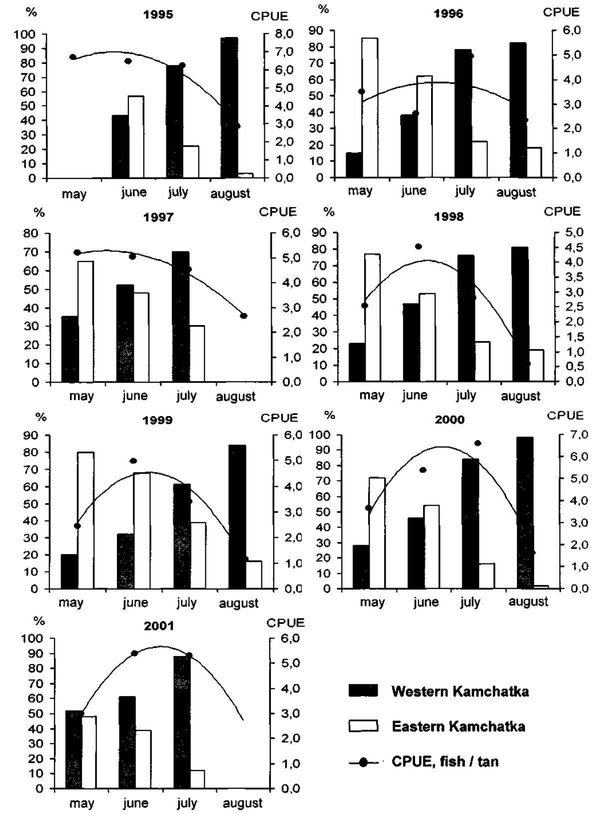
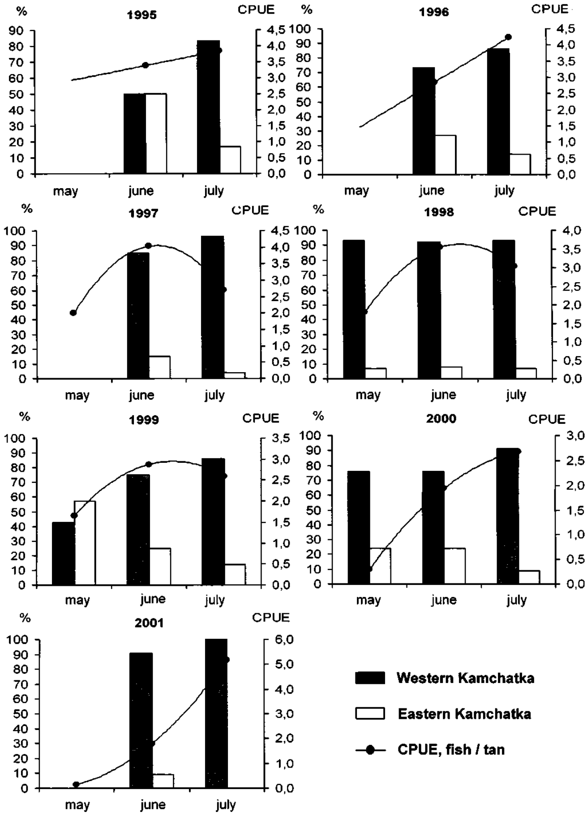


Fig. 6. Frequency dynamics of complexes of local stocks of mature sockeye salmon by main age groups from driftnet catches in the Pacific subzone – 61.03.1



observed in late June–July at the time of active migration of stocks from Ozernaya River. The mean catch was about 2–5 fish / tan in this period. Catches sometimes amounted to 6–8 fish / tan in the years of high abundance of sockeye salmon from the Ozernaya River. The latitudinal distribution of sockeye salmon in the period of pre-spawning migration in the southwestern part of Bering Sea and adjacent waters of the northwestern part of Pacific Ocean depend upon the geographical location of reproduction areas and on the timing of spawning of stocks from Eastern and Western Kamchatka. It is seen from generalized scheme of distribution, that complexes of local stocks of mature sockeye salmon are found in the Russian economic zone in the spring-summer period (Fig. 7). Interannual fluctuations in the proportions of stock compositions in driftnet catches have coincided with the dynamics of abundance of these stock complexes.

The generalized model of pre-spawning migrations of Asian sockeye salmon was made on the basis of the data from identification of local stocks of sockeye salmon, and observations of the distribution and dynamics of driftnet catches in the Russian economic zone in the May–August period (Fig. 8). Only the distribution and intensity of migration of major Asian stocks complexes are demonstrated in this scheme. This process depends mainly on the dynamics of

Fig. 7. Generalized scheme of distribution of complexes of local stocks of mature sockeye salmon from driftnet catches in spring-summer

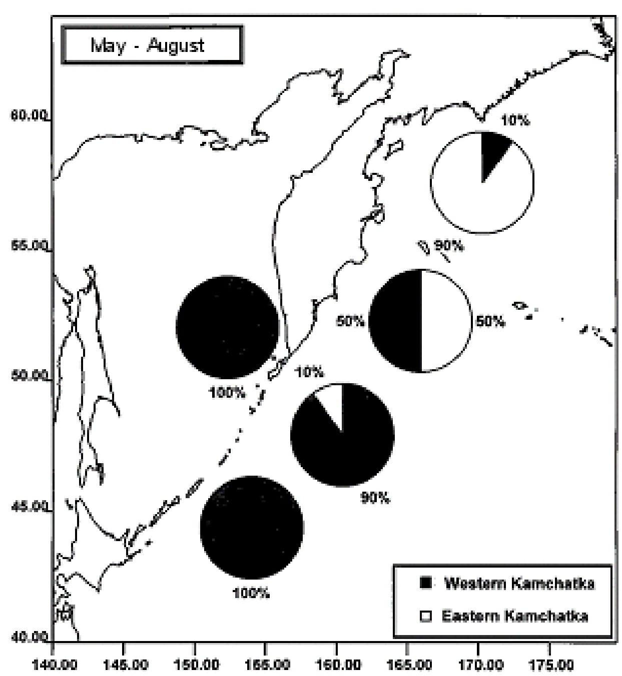
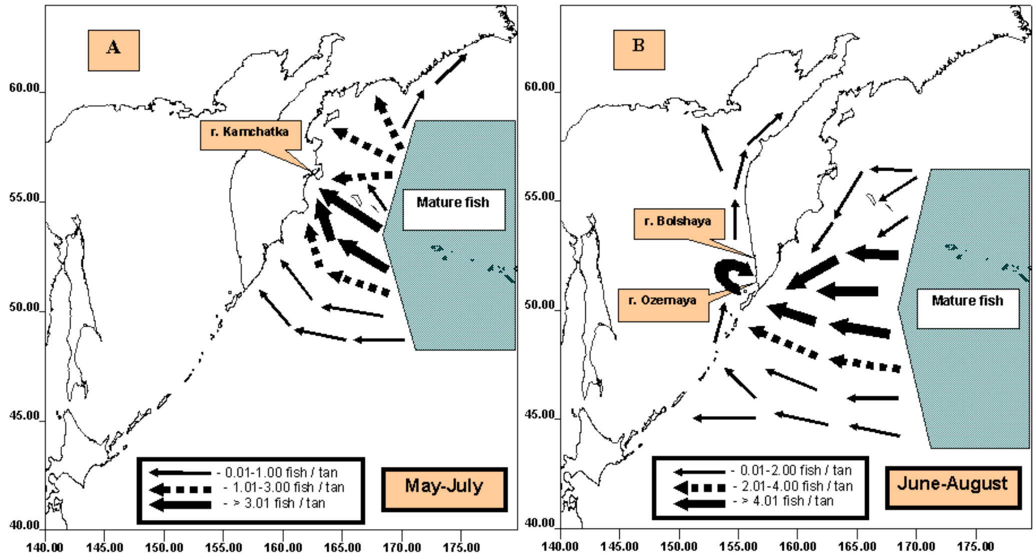


Fig. 8. Generalized model of pre-spawning migration of Asian sockeye salmon for all age groups in the Russian economic zone: A – stocks of Eastern Kamchatka; B – stocks of Western Kamchatka



abundance of stocks from the Kamchatka and Ozernaya Rivers. Sockeye salmon do not form well-defined stock complexes at the time of pre-spawning migrations, and only the broad migration front of stocks from Eastern and Western Kamchatka is shown in this scheme. A decrease in the intensity of driftnet catches of sockeye salmon at about 0.01–1.00 fish / tan is noted at the approach to the northern or southern boundary of migration fronts. The intensity of the catches average about 3.00–5.00 fish / tan in the center of the migration front. The size of the active migration front of sockeye salmon depends on stock abundance and the environment.

REFERENCES

Davis, N.D., K.W. Myers, R.V. Walker, and C.K. Harris. 1990. The Fisheries Research Institute's high-seas salmonid tagging program and methodology for scale pattern analysis. Amer. Fish. Soc. Symp. 7: 863–879.

Millar, R.M. 1987. Maximum likelihood estimation of mixed stock fishery composition. Can. J. Fish. Aquat. Sci. 44: 583–590.

Millar, R.M. 1988. Statistical methodology for estimating composition of high seas salmonid mixtures using scale analysis. (INPFC Doc. 3284) 18p. Fishery Research Institute, University of Washington, Seattle, USA.

Millar, R.M. 1990. Comparison of methods for estimating mixed stock fishery composition. Can. J. Fish. Aquat. Sci. 47: 2235–2241.