NPAFC
Doc. 1128
Rev. ______

Results of Pacific salmon trawl surveys by R/V "Professor Kaganovskii" and R/V "TINRO" during summer of 2007 in the upper epipelagic layer of northwestern Pacific

by

A. Ya. Efimkin, A.E. Lazhentsev, A.N. Starovoytov, V.V. Sviridov

Pacific Scientific Research Fisheries Centre (TINRO-center) 4, Shevchenko Alley,
Vladivostok, 690600, RUSSIA

Submitted to the
NORTH PACIFIC ANADROMOUS FISH COMMISSION
by
RUSSIA
September 2008

THIS PAPER MAY BE CITED IN THE FOLLOWING MANNER:
Efimkin A.Ya., A.E. Lazhentsev, A.N. Starovoytov, V.V. Sviridov. 2008. Results of Pacific salmon trawl surveys by R/V "Professor Kaganovskii" and R/V "TINRO" during summer of 2007 in the upper epipelagic layer of northwestern Pacific. NPAFC Doc. 1128. 13 pp. Pacific Scientific Research Fisheries Centre (TINRO-center). (Available at http://www.npafc.org).

Results of Pacific salmon trawl surveys by R/V "Professor Kaganovskii" and R/V "TINRO" during summer of 2007 in the upper epipelagic layer of northwestern Pacific

Efimkin A.Ya., Lazhentsev A.E., Starovoytov A.N., Sviridov V.V.

Pacific Scientific Research Fisheries Center (TINRO-center)

Abstract

The document describes results of Pacific salmon trawl surveys by R/V "Professor Kaganovskii" and R/V "TINRO" during the summer of 2007 in the upper epipelagic layer of northwestern Pacific. Similar to previous year of research (2004 and 2006), the major purpose of upper epipelagic trawl survey of northwestern Pacific was the total estimation of adult pink salmon (primarily of Okhotsk Sea stocks) abundance during its preanadromous migration. Generally, the spatial extent of 2007 survey was similar to that of 2004 and 2006 surveys, incorporating waters off Kuril Islands and high-seas areas of northwestern Pacific beyond EEZ towards northern boundary of Subarctic Front. During the survey 68 trawl stations were carried out in upper 40 meters layer. This enabled collection of information on upper epipelagic layer's nekton community composition and structure during preanadromous migrations of Pacific salmon. The research results provided data on species composition, Pacific species percentages in catches and associated biological parameters. Also information on stomach contents for salmon and other species forage base and hydrological environment was collected. Information on abundance and biomass of all species of nekton and macrozooplankton was obtained.

Material and methods

The trawl survey was conducted by r/v "Professor Kaganovskii" and R/V "TINRO" from June 7 to July 1 to estimate pacific salmon abundance and distribution in the North Pacific Ocean in summer 2007. It encompassed an area 883 km^2 and consisted of 68 trawl tows. Trawling hauls were conducted with a midwater trawl RT 80/396. Its mouth dimensions are following: vertical – 35-37 m, horizontal – 31-36 m, cone-end was equipped with 10-mm mesh on the inside. The trawl has being usually towed by the sea surface during one hour, maintaining a speed 4.4-5.0 knots. The trawlings were round-the-clock. To achieve the required parameters of research vessel trawling system the trawling course was adjusted according to weather and hydrological conditions. The trawl hydrodynamic plate was maintained at 0 m level (the position of the plate was verified by acoustic readings and by sight), while the length of warps was 245-280 m. The abundance (in millions of individuals) and the biomass (in thousands of tons) of fishes and cephalopods were calculated by multiplying the average density (individuals/km^2) and mass (kg/km^2) for the particular species times area of the biostatistical region. The trawlings with the extremely high catches were considered only for the area of trawlings, and these results were extrapolated for the region as a whole.

Oceanographic conditions were sampled at the same approximate location of the trawl tows aboard R/V TINRO. The R/V TINRO used a "Neil Brown" MARK-II CTD to measure temperature and salinity to a maximum depth of 1000 m.

The salmon feeding was examined in groups according to body size – 21 to 30 cm, 31 to 40 cm, 41 to 50 cm, 51 to 60 cm, and greater than 61 cm. The samples including from 10 to 25 stomachs of the same body size group were selected from catches and processed without any prior fixation. Upon weighting the sample the species composition of food, the percentage of most numerous species and other typical parameters were analyzed. The stage of food digestion was evaluated using 5-step scale. The index of stomach fullness was calculated as relation of food mass in the stomach divided by fish body weight times 10000. The daily food intake was calculated with due regard to feeding peaks. Thus, the daily food intake was counted as overall sum of all prey consumed for every period of time studied.

Results and Discussion

Spatial distribution, abundance, and biomass of Pacific salmon in northwestern Pacific during summer of 2007.

During the survey period 41 fish species of 26 families, 13 squid species of 7 families, and 6 jellyfish species were recorded in catches during the survey.

In total estimates of nekton and jellyfish species within survey area of northwestern Pacific amounted to 2.16 mln. t. Similar to previous years, the majority of biomass estimate was attributed to nekton fish species (83 %), Cephalopoda were accounted for 15 %, and the rest was composed of jellyfish species. Pacific salmon attributed to 29% of total nekton species abundance with a pink salmon being dominant among them (23.5%).

Pink salmon. In 2007, similar to previous years, in-season and near real-time data of research vessels was successfully utilized for fishery forecast on pink salmon. In 2007 the record (in terms of entire history of such surveys) number of returning pink salmon adults was recorded. Pink salmon abundance and biomass amounted to 451.54 mln. inds. and 490.70 th. t. This is higher by 125 mln. inds. and 100 th. t compared to even years of 2004 and 2006. Pink salmon percentage among other species (nekton and jellyfish species combined) has increased significantly, reaching 23 % (2004 – 13 %, and 2006 – 15 %). Despite of early survey timing (start of survey — June 7), pink salmon distribution was relatively broad within survey area. Pink salmon abundance exhibited gradual decrease in relative abundance from coastal into high-seas waters throughout the survey area (Fig. 1). Unlike previous years of research, almost no zero catches of pink salmon were recorded during 2007 survey (except for 2 stations at the south-western margin of the survey area). In 2007, unlike in previous surveys, extremely high catches were also observed. Only 2 stations had CPUEs higher than 200 inds./hour (235 and 275 inds./hour). Over 50% of trawl tows had catches of 50-200 inds./hour (Fig. 1). Therefore, in 2007 pink salmon exhibited relatively uniform distribution and stably high relative abundance**.**

Spatial distribution of average length and body weight was relatively nonuniform. Largest individuals were caught nearby southern Kuril Islands. Their average length ranged between 46-48 cm, and some males were as large as 58 cm. Small-sized pink salmon (average - 43-44 cm) was dominant in the central part of survey area. The rest of survey area was dominated by pin salmon with an average body length of 44-46 cm.

Discriminate analysis was employed to find boundary values for gonad-somatic indices (GSI for females – 5.115 % and 2.250 % for males). This analysis allows to separate pink salmon into two distinct subsets. Pink salmon with a GSI below that boundary belongs primarily to late spawners of Sakhalin-Kuril region. The early spawners attributed for 29 %, late spawners – 71 % of all estimates. Table 1 lists biological parameters of these two subsets f pink salmon (discriminated on the basis of

GSI). It is evident that length and body weight of late and early spawners distinctly differ for both sexes. Pink salmon with higher GSI had lower values of these parameters, whereas pink salmon with a low GSI exhibited reversed pattern. This coincides well with differences in average FL and BW between stocks of western Kamchatka and northern Okhotsk Sea coast and stocks of Sakhalin-Kuril region. Coastal catches data speaks for higher FL and BW of pink salmon of Sakhalin-Kuril Island.

This analysis allowed updating in-season fishery strategies of respective regions, which helped to achieve Sakhalin-Kuril Island region catches of record quantity (compared to recent years catches in this region).

The 2007 survey was less favorable for accounting total abundance of other species of Pacific salmon (as compared to pink salmon). For example, migratory activity of chum salmon is very changeable and exhibits a wave-like pattern. First massive inflow of chum salmon into Kuril region occurs in late May-early June. Second peak of abundance occurs in late July-August.

During summer of 2007 mature chum salmon age structure was constituted by age groups ranging from 0.2 to 0.4. The age group of 0.3 was dominant everywhere. Abundance and biomass estimates of mature chum salmon reached 37.9 mln. inds. and 78.3 th. t, respectively. Its distribution is shown in figure 2.

Immature chum was represented by three age groups: 0.1 through 0.3. Individuals aged 0.2 and 0.3 were dominated catches. Figure 3 provides immature chum salmon distribution. Average FL of immature chum (Fig. 4) clearly exhibits trend of decrease in eastern direction (from 55 cm down to 37). In the western regions immature chum salmon was represented primarily by 0.3 (FL 49-55 cm), whereas in they eastern regions — by 0.2 (35-36 cm).

During the surveys in previous years inshore areas were dominated by 0.3 chum salmon, with a trend of increase of younger age classes in more offshore areas.

Survey in 2007 provided estimates of immature chum salmon within the area surveyed as 20.54 mln. inds. and 25.59 th. t.

During 2007 survey mature chum salmon abundance and biomass were estimated to be somewhere between of that in 2004 and 2006 . Immature chum salmon abundance was similar to that during previous years of research.

Sockeye salmon. During June-early July of 2007 sockeye salmon was observed only northeastern part of survey area. This species was recorded in 5 trawl tows only with only one of them being 1 inds./hour (Fig. 5). Other trawl tows contained only single individual of sockey salmon in catch.

FL varied within 55.6-59.1 cm. Females dominated catches (5 out of 6 individuals caught). During June-early July of 2007 sockeye salmon abundance and biomass within the survey area was estimated to be 0.66 mln. inds. and 1.72 th. t.

Chinook salmon. Immature chinook salmon catches were not high (1-2 inds./hour). Large-sized individual dominated catches (53.4-79.6 cm). Individual specimen with FL of as low as 33 cm was recorded at single station only. Chinook salmon catch rates, and size composition in 2007 was similar to that during 2004 and 2006 surveys. During June-early July of 2007 sockeye salmon abundance and biomass within the survey area was estimated to be 0.7 mln. inds. and 1.76 th. t.

Coho salmon. Major concentrations of coho salmon were observed nearby the outer boundary of Russian EEZ, with CPUEs reaching 5 inds./hour. This indicates that during 2007 survey only the very beginning of preanadromous migrations of coho salmon took place (Fig. 5). FL varied within 49-62 cm, with a fish of FL 51-58 cm being the most dominant. Average FL was 53.7 cm. Females dominated catches (77 %). GSI were low. During June-early July of 2007 sockeye salmon abundance and biomass within the survey area was estimated to be 2.61 mln. inds. and 4.77 th. t.

Feeding of pink and chum salmon

Copepods (*Neocalanus cristatus*), Euphausiids (*Thysanoessa longipes, Th. inspinata*) and fishes constituted the majority of pink salmon diet (with FL<40 cm) (Table. 2). Pink salmon with FL<40 cm feeding intensity was average one, with stomach fullness indices (SFI) being 80 ‱ on average.

Pink salmon of FL=41-50 cm was feeding primarily on copepods, euphausiids pteropods (Table 2). Daily feeding dynamics had two peaks (SFI >300 ‱): first between 12-00 and 15-00 when pteropods (*Limacina helicina*) were primary food items and second in the evening time with *Thysanoessa inspinata* being the primary food item.

Percentage of euphausiids was highest in the diet of large-size (over 50 cm) pink salmon – 60.3 % (Table 2). Unlike smaller individuals, it consumed primarily *Euphausia pacifica*. Second by the order of importance were copepods 27.1 % (Table 2), similar to smaller size pink salmon.

Therefore it can be concluded, that despite of broad spectrum of items consumed, the 90% of pink salmon diet was attributed to three Euphausia species, two copepod species and one pteropod species (*Limacina helicina).* These food items are valuable in terms of their high caloric content.

The total food consumption, which can serve as an indicator of this species impact upon the ecosystem, amounted to 16.429 th. t per day.

Chum salmon in catches had a broad range of FL - from 36 to 64 cm (respectively, the results for 4 size groups are provided).

The majority of food ratio of 31-40 cm chum salmon (immature 0.1 individuals) was constituted by appendicularians and chaetognaths (Table 3). Food ratio of 0.2-0.3 chum salmon (FL-41-50 cm) was primarily composed of 4 groups of species, among which Cnidaria and Ctenophora (primarily, Ctenophora) and pteropods (Limacina helicina) were dominant ones (Table 3).

Feeding behavior of 51-60 cm chum salmon resembled in many aspects that of 41-50 cm chum salmon. In other words, the majority of food ratio was composed of ctenophores and pteropods. Euphausiids and appedicularians, which were consumed during latter half of the day, were of secondary importance (Table 3).

Chum salmon is the only Pacific salmon species which consumes jellyfishes in large quantities. It enables chum salmon to avoid food competition with highly abundant pink salmon. In addition, chum salmon is known for highly active digestive enzimes, which allows this species to digest quickly jellyfish species

For largest chum salmon (FL>60 cm) jellyfish species were of a lower importance and their consumption was equal to that of pteropods (i.e. 19.4 %) (Table 3). The primary food items were euphausiids (primarily, Thysanoessa inspinata).

The percentage of copepods in chum salmon diet was remarkably low, though their were highly abundant in diets of other pelagic fishes (pink salmon, in particular).

Chum salmon daily feeding dynamics was vaguely expressed with a two periods of slightly higher feeding intensity — during morning and evening periods.

Table 1

Biological parameters of pink salmon with low and high GSI

Sex	**Fertility**	**Length, cm**		**Weight, g**		**GSI, %**		**N**
		average	***95%***	***average***	***95%***	***average***	***95%***	
Females	GSI <5.115%	44.41	0.12	1076	11	3.39	0.08	671
	GSI >5.115%	43.97	0.14	1088	12	6.70	0.11	510
Males	GSI <2.250%	45.23	0.16	1166	15	0.96	0.03	1079
	GSI >2.250%	43.60	0.40	1087	32	3.35	0.14	217

Table 2. Feeding (in %) of pink salmon during summer of 2007

Food items	Size group		
	31-40	**41-50**	**51-60**
Euphasiidae	***20.6***	***32.7***	***60.3***
Thysanoessa longipes	6.1	4.1	2.2
Th. inspinata	12.6	21.6	21.1
Euphausia pacifica	1.9	6.9	37.0
Amphipoda	***11.3***	***5.1***	***0.4***
Themisto pacifica	11.0	4.5	0.2
Primno macropa	0.3	0.4	0.2
Hyperia		0.2	
Copepoda	***52.1***	***37.2***	***27.1***
Neocalanus plumchrus			3.5
N. cristatus	52.1	31.2	20.7
Eucalanus bungii		6.0	2.9
Decapoda	***0.0***	***0.3***	***0.0***
Megalopa		0.2	
Decapoda sp.		0.1	
Pteropoda	***1.2***	***16.9***	***9.4***
Clione limacina		0.1	0.1
Limacina helicina	1.2	16.8	9.3
Heteropoda	***0.0***	***0.6***	***0.0***
Heteropoda gen. sp.		0.6	
Oikopleura	***0.0***	***0.2***	***0.0***
Oikopleura labradoriensis		0.2	
Sagitta	***0.1***	***1.8***	***0.0***
Sagitta elegans	0.1	1.8	
Other	***0.0***	***0.2***	***0.0***
Polychaeta sp		0.2	
Squids	***0.0***	***2.1***	***0.1***
Gonatus sp		0.3	
Gonatopsis sp		0.1	
Cephalopoda sp		1.7	0.1
Fishes	***14.7***	***2.9***	***2.7***
Pleurogrammus monopterigius	1.5	0.7	0.7
Stenobrachius leucopsarus	11.7	1.6	1.1
Myctophidae			0.9
Hemilepidotus sp.	1.5	0.5	
Average SFI, ‱	**74.7**	**89.8**	**128.1**
Average body length, cm	**38.6**	**44.5**	**52.3**
Average body weight, g	**762.4**	**1107.9**	**1912.4**
Fresh food, %	**52.8**	**71.8**	**70.9**

Table 3. Feeding (in %) of chum salmon in summer 2007

Food items	**Size group**			
	31-40	**41-50**	**51-60**	**61-70**
Euphasiidae		***2.6***	***7.1***	***43.4***
Thysanoessa longipes		0.1	1.0	8.1
Th. inspinata		1.3	4.1	30.3
Euphausia pacifica		1.2	1.9	5.0
Amphipoda	***12.8***	***1.3***	***1.1***	***1.4***
Themisto pacifica	12.8	0.1	0.2	0.0
Primno macropa		1.1	0.9	1.4
Hyperia		0.1	0.1	0.0
Copepoda	***9.1***	***8.6***	***1.4***	***1.6***
Neocalanus plumchrus		0.1	0.0	0.0
N. cristatus	8.8	2.0	0.3	1.6
Eucalanus bungii	0.3	6.5	1.1	0.0
Pteropoda	***1.7***	***26.7***	***21.1***	***19.4***
Clione limacina		13.8	11.2	3.6
Limacina helicina	1.7	12.9	9.9	15.8
Heteropoda		***0.0***	***0.5***	***0.0***
Heteropoda gen. sp.		0.0	0.5	0.0
Oikopleura	***31.5***	***9.2***	***8.9***	***5.1***
Oikopleura labradoriensis	31.5	9.2	8.9	5.1
Sagitta	***37.2***	***12.6***	***0.3***	***0.0***
Sagitta elegans	37.2	12.6	0.3	0.0
Other	***5.4***	***6.0***	***2.5***	***6.3***
Polychaeta sp	5.4	6.0	2.5	6.3
Gelatinous zooplankton	***2.3***	***32.4***	***54.8***	***19.4***
Beroe cucumis		1.4	24.9	19.4
Coelenterata	2.3	17.4	21.7	0.0
Aglantha digitale		13.6	8.2	0.0
Squids		***0.6***	***0.3***	***0.5***
Cephalopoda sp		0.6	0.3	0.5
Fishes		***0.0***	***2.0***	***2.9***
Pleurogrammus monopterigius		0.0	0.0	0.0
Stenobrachius leucopsarus		0.0	1.9	2.9
Hemilepidotus sp.		0.0	0.1	0.0
Average SFI, ‰o	**69.3**	**65.4**	**67.7**	**65.7**
Average body length, cm	**36.0**	**46.7**	**54.0**	**64.1**
Average body weight, g	**527.0**	**1216.8**	**1972.0**	**3259.1**
Fresh food, %	**63.3**	**34.2**	**28.6**	**41.5**

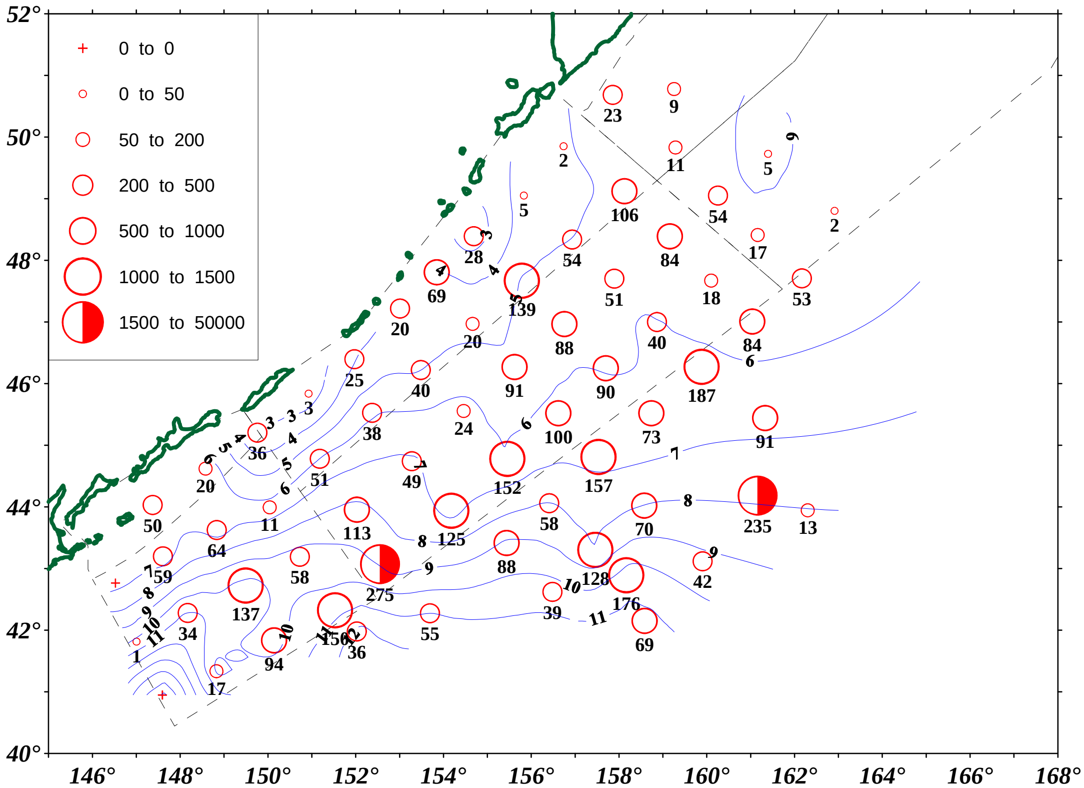

Fig. 1. Spatial distribution of pink salmon (inds./sq. km) during June 7 –July 1, 2007. Numbers – catch (inds./hour). Isolines indicate SST.

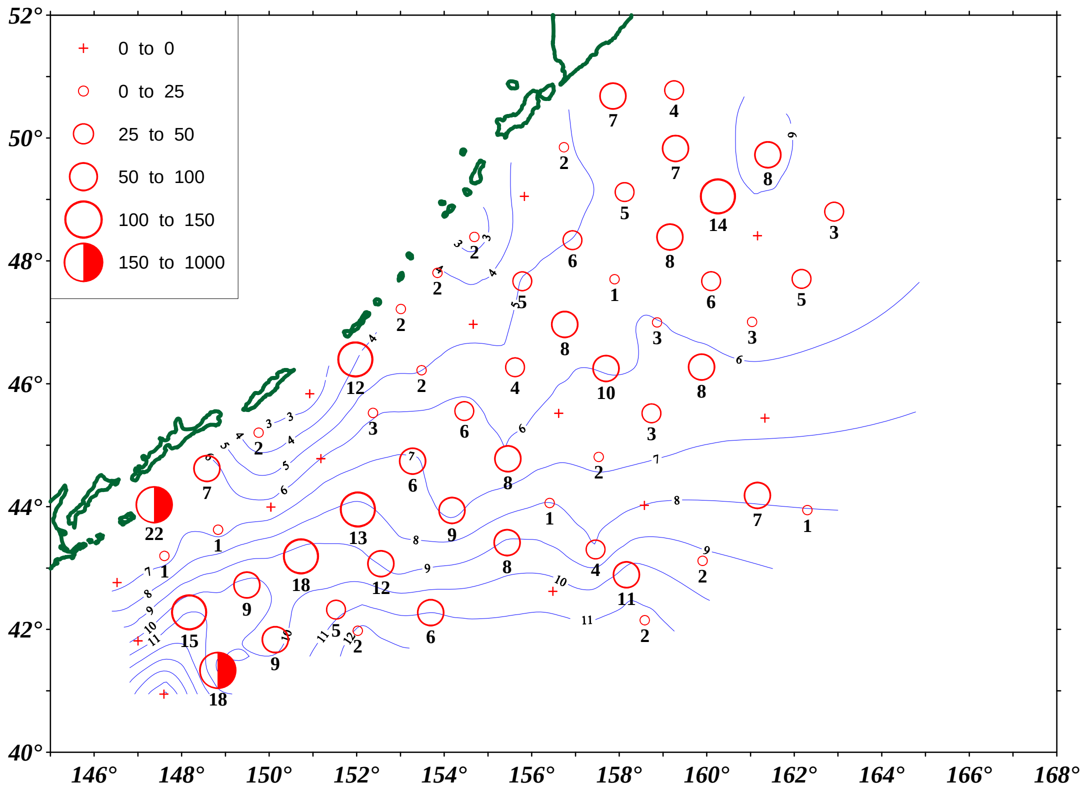

Fig. 2. Spatial distribution of mature chum salmon (inds./sq. km) during June 7 – July 1, 2007. Numbers – catch (inds./hour). Isolines indicate SST.

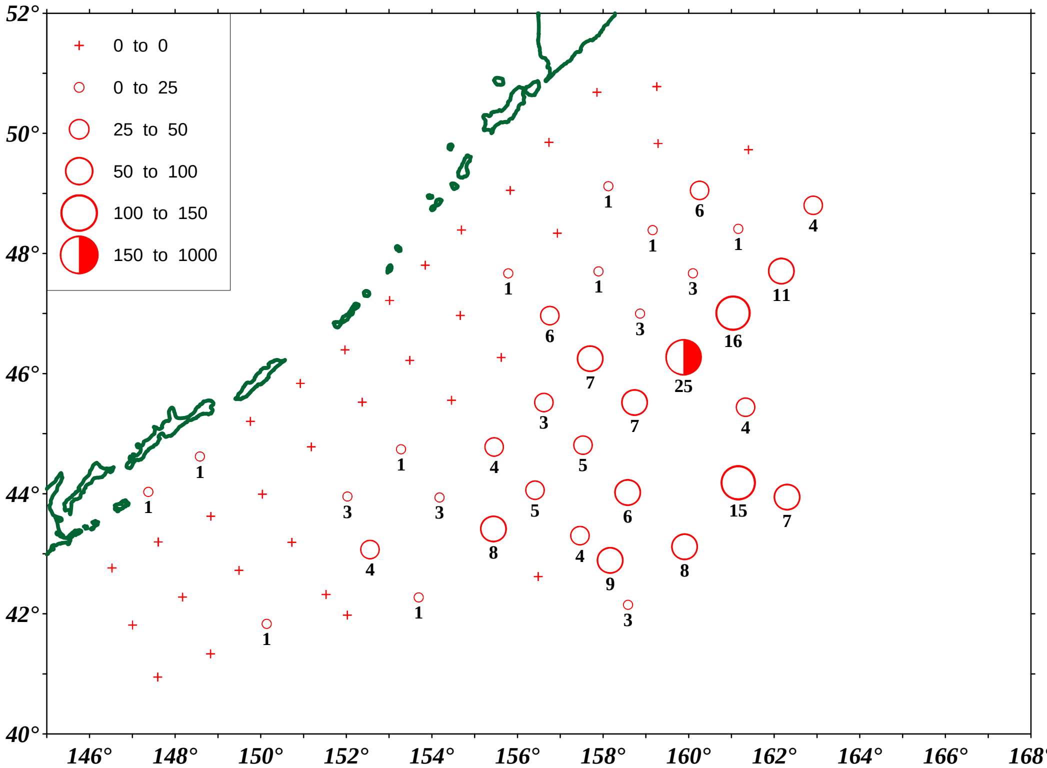

Fig. 3. Spatial distribution of immature chum salmon (inds./sq. km) during June 7 –July 1, 2007. Numbers – catch (inds./hour).

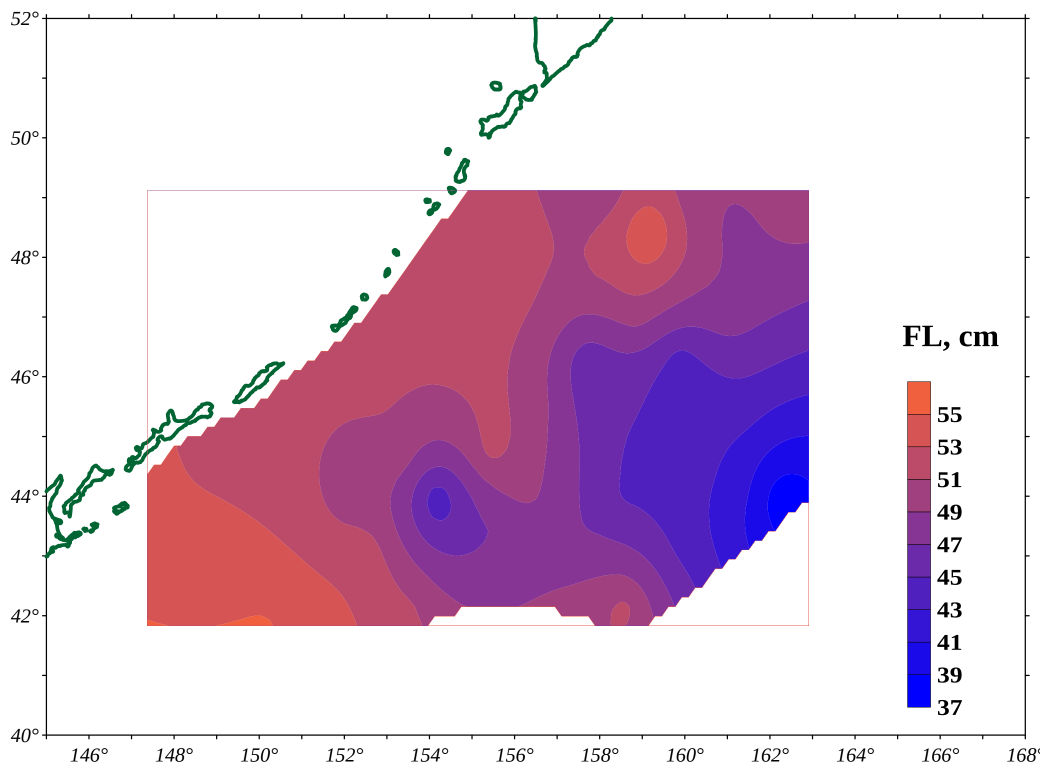

Fig. 4. Spatial distribution of immature chum salmon average fork length.

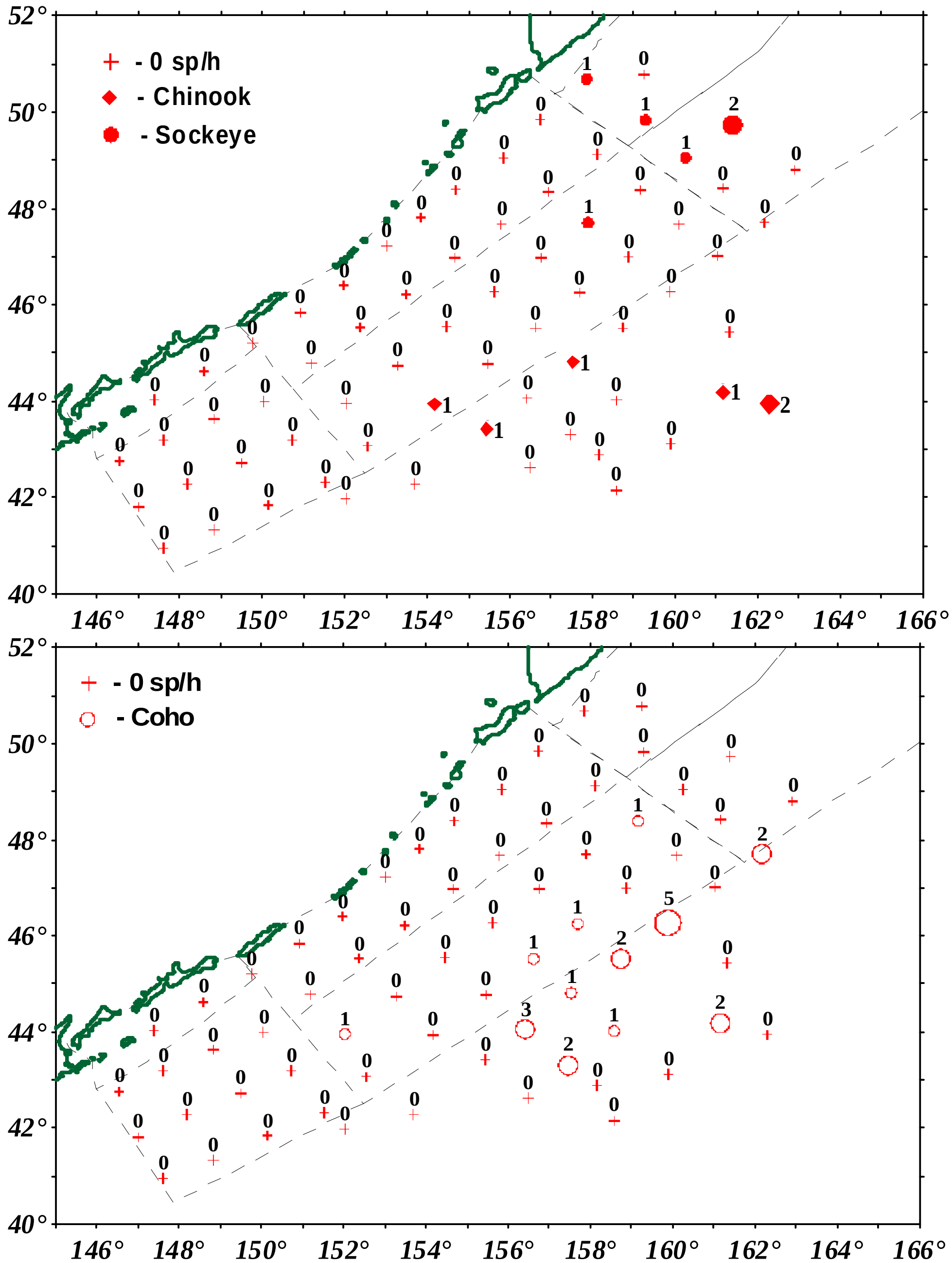

Fig. 5. Spatial distribution of sockeye and chinook salmon (upper figure) and coho salmon (lower figure) during June 7 –July 1, 2007. Numbers – catch (inds./hour).