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Results of the 1983 U.S. and U.S.S.R. Bottom Trawl Surveys in the Eastern Bering Sea

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ABSTRACT

Research vessels from the United States and the Soviet Union concurrently sampled the traditional Northwest and Alaska Fisheries Center resource assessment survey grid in the eastern Bering Sea during summer 1982. The purpose of this report was to determine the feasibility of combining the two data sets to improve the assessment data for groundfish. Methods used on each nation's vessel are described and abundance estimates and biological characteristics derived from the two surveys compared. Conclusions were that the data were generally not compatible and could not be combined.

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INTRODUCTION

The Northwest and Alaska Fisheries Center (NWAFC) has conducted resource assessment surveys in the eastern Bering Sea since 1971. To provide more comprehensive assessments of the Bering Sea groundfish resources, cooperative surveys were begun in 1979 with the Far Seas Fisheries Research Laboratory (Shimizu, Japan). In 1982, a research vessel from the U.S.S.R. joined the U.S. and Japanese vessels to expand the sampling area northwest into the Soviet fishery zone. The cooperative surveys with Japan have been closely coordinated efforts, while the Soviet vessels have worked more independently.

In 1983, the Soviets again sent a research vessel to the eastern Bering Sea. During this second survey, the U.S.S.R. vessel essentially followed the station pattern of the U.S. vessels. Two U.S. observers were aboard the Soviet vessel throughout the survey, collecting catch and biological data which were returned to the NWAFC for analysis. The purpose of this report is to present results of the 1983 Soviet survey effort and compare them with the findings from the 1983 NWAFC survey. This presents an opportunity to determine the compatibility of results from the U.S. and U.S.S.R. surveys and investigate the feasibility of combining this data to provide a better assessment of Bering Sea groundfish resources.

SURVEY METHODS

Survey Area

The 1983 survey area extended from the southern reaches of the eastern Bering Sea continental shelf, north to St. Matthew Island, and from the 200 m isobath to shoreline proximity. A systematic station pattern, established by the NWAFC in earlier years, was sampled by vessels from both nations. The survey area was divided into seven subareas. Table 1 shows the total area of each. subarea and the actual and planned sampling density. The comparative value of data from subarea 5 is limited because. of the differences in the extent of sampling in 'this area by the U.S. and U.S.S.R. vessels; therefore, the hauls in this subarea were removed from the final analysis.

In all, the U.S. vessels occupied a total of 354 good performance stations and the U.S.S.R. vessel, 348 stations. Stations sampled by U.S. vessels to increase sampling density of crab populations around the Pribilof Islands and St. Matthew Island, were removed from the analysis, creating equal sampling effort throughout the survey area and facilitating the comparison between the Soviet and U.S. survey data. In the final analysis, after stations deeper than 200 m and opportunistic tows were deleted, 310 data collection points were used from the U.S.. survey (Fig. 1) and 315 stations were used for analysis of the U.S.S.R. data (Fig. 2).

Fishing Vessels and Gear

Two vessels were used by the United States to conduct the 1983 Bering Sea survey: the NOAA ship Chapman and the chartered vessel Alaska. The U.S.S.R. used one trawler, the Milogradovo. Vessel characteristics and survey durations are listed in Table 2. The U.S. vessels were both equipped with 83-112 eastern trawls, while the Soviets used one of their commercial fishing trawls. Table 3 summarizes the characteristics of the two trawls. Path widths, while fishing, were from 16.4 to 16.5 m for the two U.S. trawls and 29.5 m for the Soviet trawl: vertical openings were 2.3 m while fishing with the 83-112 trawl and 6.0 m while fishing with

Table 1.--Size of subareas used during the 1983 U.S. and U.S.S.R. eastern Bering Sea survey, including planned and actual sampling densities by subarea.

Subarea	Area (km^2)	Proportion of total area	Planned sampling density		Actual U.S. sampling density		Actual U.S.S.R. sampling density	
			No. stns.	km^2/stn.	No. stns.	km^2/stn.	No. stns.	km^2/stn.
1	78,808	0.146	59	1,336	58	1,359	59	1,336
2	60,343	0.112	47	1,284	45	1,341	45	1,341
3	48,168	0.089	46	1,047	32	1,505	33	1,460
4	91,206	0.169	68	1,341	74	1,233	68	1,341
5	97,425	0.180	33	2,952	20	4,871	28	3,479
6	82,405	0.153	57	1,446	58	1,421	57	1,446
7	81,462	0.151	61	1,335	67	1,216	58	1,405
Total survey area	539,817	1.000	371	1,455	354	1,525	348	1,551

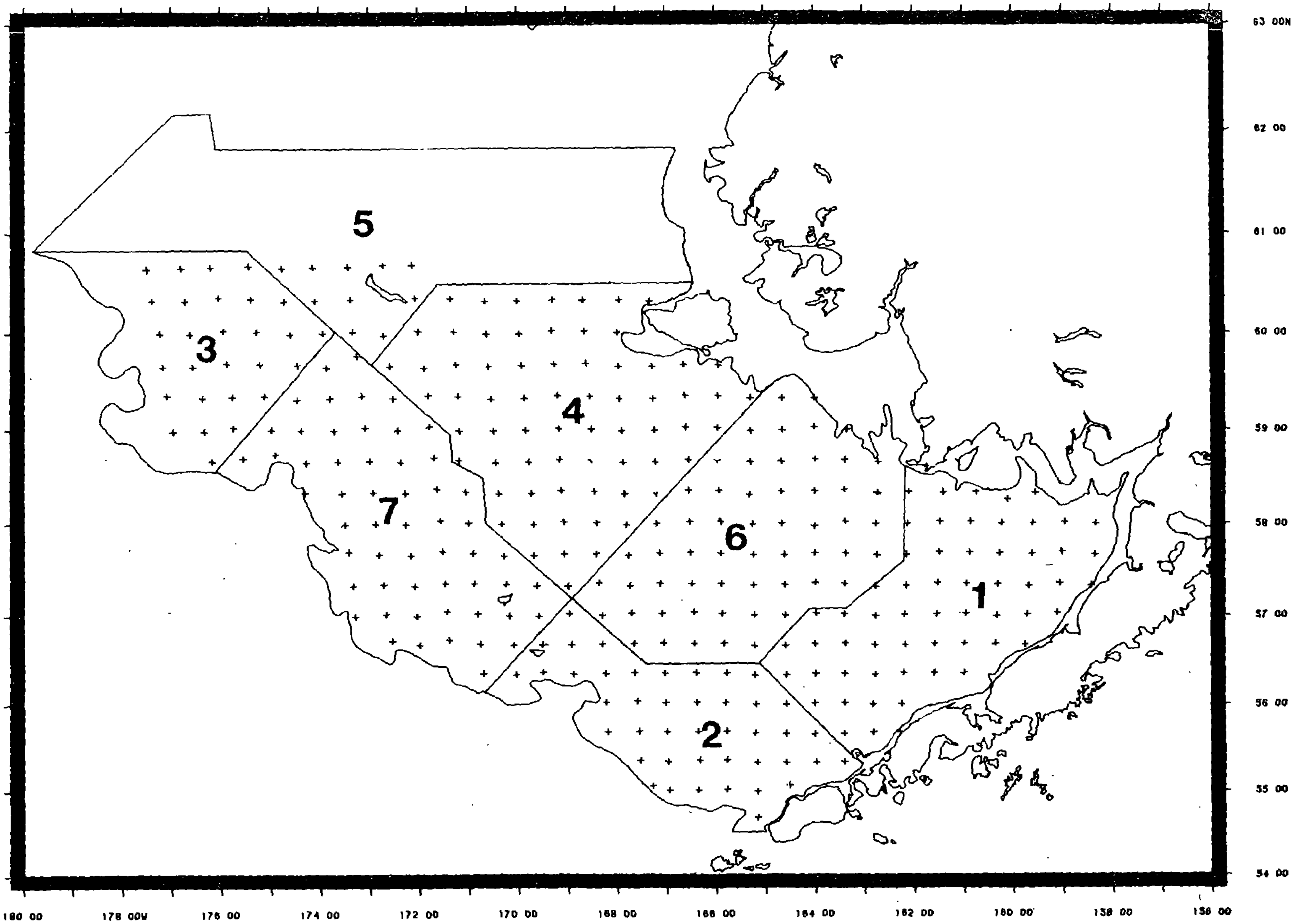

Figure 1.--Stations occupied by U.S. research vessels during the 1983 eastern Bering Sea survey and stratification used for analysis.

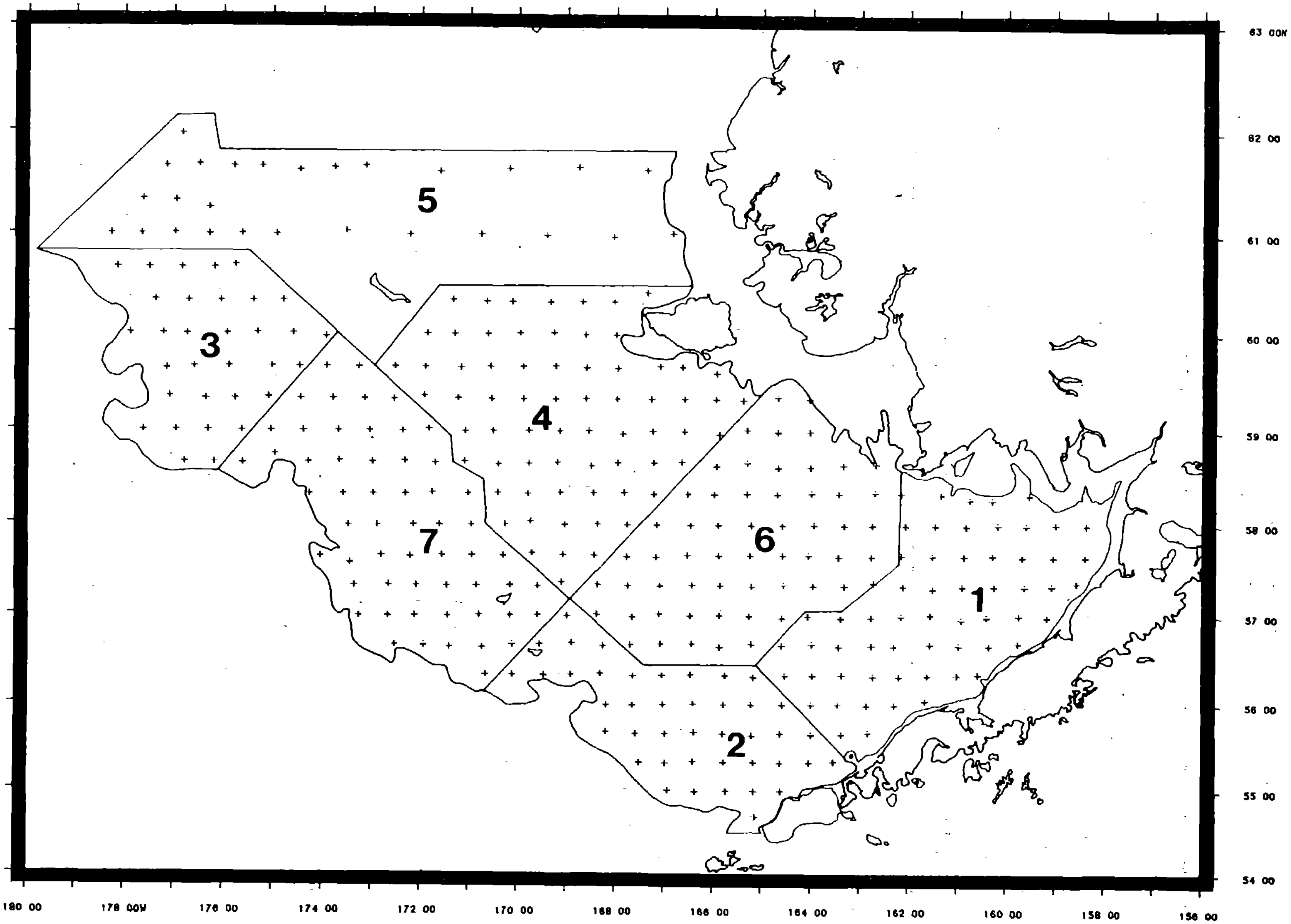

Figure 2.--Stations occupied by the U.S.S.R. research vessel during the 1983 eastern Bering Sea survey and stratification used for analysis.

Table 2.--Vessels participating in the 1983 U.S. and U.S.S.R. eastern Bering Sea bottom trawl surveys.

Vessel	Overall length (m)	Gross tonnage	Horsepower	Survey period Start	Survey period Finish
R/V Alaska	30.5	193	600	7 June	1 August
R/V Chapman	38.7	427	1,165	8 June	1 August
F/V Milogradovo	82.0	2,654	2,320	15 June	19 August

Table 3.--Bottom trawls used during the 1983 U.S. and U.S.S.R. eastern Bering Sea surveys.

Trawl type	Headrope length (m)	Footrope length (m)	Opening vert. (m)	Opening horz. (m)	Mesh sizes Wing (mm)	Mesh sizes Square (mm)	Mesh sizes Belly (mm)	Mesh sizes Codend (mm)	Mesh sizes Codend liner(mm)	Accessory gear Door (m)	Accessory gear Dandyline length(m)
83-112	25.3	34.1	2.3	16.5	102	102	89	89	32	1.8 x 2.7	54.9
Milogradovo trawl	43.0	60.8	6.0	29.5	100	90	60	30	--	2.76 (diam.)	50.0

the U.S.S.R. gear. Roller gear, consisting of 40 bobbins each 30 cm in diameter, was used on the *Milogradovo* trawl; it was apparently used only on rocky or uneven ground and no records were kept to identify these stations. No roller gear was used on either U.S. vessel.

Sampling Methods and Data Collection

Standardized sampling procedures have been followed for many years during NWAFC surveys; a detailed description can be found in Smith and Bakkala (1982) and Wakabayashi et al. (1985). A brief accounting will be included here.

Tow duration was always 30 minutes unless circumstances required that the gear be retrieved sooner. Generally, catches up to 1 metric ton (t) were completely processed while larger catches were subsampled. Catches were sorted by species, and weights and numbers of each species were recorded. For the large catches that were subsampled, the subsample weights and numbers were expanded to the entire catch. A random sample of commercially important fish species was also measured and sexed, and otoliths or scales were removed for later age analysis. All physical data (Including station positions, time, date, surface and bottom water temperatures) and biological data (excluding specimen ages) were entered into shipboard computers.

The sampling procedures on the U.S.S.R. vessel were based on the NWAFC standardized procedures but variations occurred to accommodate larger catches. Samples containing 1 t or less were completely processed,, in keeping with U.S. procedures. When large catches (95-99%) of walleye pollock, *Theragra chalcogramma*, were encountered, two baskets of pollock were collected from each net area: front, middle, and end. These six baskets were then mixed and the entire sample or a subsample was used to determine pollock weights and numbers. In these cases, total pollock catch weights were supplied by the factory personnel. Total numbers in the catch were determined by expanding the subsample numbers to the entire catch. All other species were entirely removed from the catch and processed.

Catches on the inner Bering Sea shelf were mainly composed of 4-5 flatfish species. When the amount of fish caught ranged between 1 and 2 t, all of the walleye pollock and Pacific cod, Gadus macrocephalus, were removed from the catch and weights and numbers determined. A subsample of the flatfish was taken, usually a half or quarter of the total catch (visually determined). When the entire catch was in the 2-5 t range, the walleye pollock and Pacific cod were again entirely processed 'but only a subsample of six baskets of the remaining flatfish and other species was processed. The total catches of these latter species were also derived from factory figures. In a few instances, estimates of total catch weight made by the vessel captain were used when the factory was not functioning and therefore unable to supply catch weights. All data were recorded on paper forms and later transferred to the computer at the NWAFC.

While a standard subsampling procedure was used aboard U.S. vessels to obtain random samples for length data collection (Hughes 1976), the methods used on the Soviet vessel were different and may have resulted in more bias. Catch subsampling gear (fish bins, catch splitting nets, large capacity scales) were not available on the U.S.S.R. vessel, as they were on the U.S. vessels, and partitioning of the catch was done visually. At the beginning of the cruise, the catch was dumped on the deck and subsamples were obtained with fish-picks. Later, shovels were used to collect subsamples. Both of these methods may have introduced bias to the randomness of the sample. Total weights for large catches of pollock and flatfish were derived, from the average weights of frozen fish blocks and the percent of recovery after processing.

In total, 290,422 fish were measured from 20 different species (Table 4). Nearly twice as many were measured on the U.S. vessels (180,070) as on the U.S.S.R. vessel (110,352). Close to 6,000 age structures, from nine species, were collected on U.S. vessels (Table 5); no age data were obtained on the U.S.S.R. survey.

Data Analysis

Detailed descriptions of methods of analysis are given by Bakkala and Smith (1978) and Wakabayashi et al. (1985). In general terms, catches at each station were standardized to a basic sampling unit (kg/ha,ha = hectare or 10,000 m^2) trawled. Mean CPUE values by species and strata were then computed from the standardized catch rates. After being weighted by the size of each strata, these were summed to obtain mean catch rates for the overall survey area. Standing stock (biomass) estimates were derived using the "area swept" method of Alverson and Pereyra (1969). Vulnerability of all species to the trawls were assumed to be 1.0. This methodology was used when analyzing the data from both the U.S. and U.S.S.R. surveys.

In estimating the length composition of the sampled populations, the number of individuals within the sex and size classes at each station was derived by expanding the length-frequency subsample to the total catch per standard sampling unit. The individual station data were then expanded to the total strata area and summed over strata to obtain estimates for the total survey area. Age composition was estimated by proportioning

Table 4.--Numbers -of fish-measured during the 1983' U.S. and U.S.S.R. eastern Bering Sea trawl surveys.

Species	U.S. survey	U.S.S.R. survey
Walleye pollock	78,033	57,419
Pacific cod	11,353	5,325
Yellowfin sole	33,924	39,709
Flathead sole	17,284	1,189
Rock sole	16,285	2,610
Alaska plaice	11,624	1,378
Arrowtooth flounder	6,889	-
Pacific halibut	996	1,675
Greenland turbot	951	-
Bering flounder	-	104
Pacific herring	2,202	471
Sablefish	155	-
Rex sole	82	-
Longhead dab	157	-
Saffron cod	135	225
Sparse toothed lycod	-	82
Shortfin eelpout	-	50
Capelin	-	110
Chum salmon	-	3
Chinook salmon	-	2
Total	180,070	110,352

Table 5.--Approximate number of age structures collected on U.S. vessels during the 1983 Bering Sea survey.

Species	Chapman	Alaska	Total
Walleye pollock	1,083	906	1,989
Pacific cod	---	747	747
Yellowfin sole	411	328	739
Greenland turbot	335	--	335
Flathead sole	590	--	590
Rock sole	--	452	452
Alaska plaice	--	369	369
Arrowtooth flounder	593	--	593
Pacific herring	25	129	154
Total	3,037	2,931	5,968

the computed population length-frequency distributions to ages using age-length keys that were stratified by sex and size categories. Age data are not presented in this report because comparative data were not taken on the U.S.S.R. vessel.

The U.S. vessels surveyed alternate rows of the grid pattern and these catch rates were compared (Hirschberger, in press). In the analysis of the U.S. data, CPUE values were scaled to the most efficient vessel for those species where significant differences were found between catch rates (Geisser and Eddy 1979), under the assumption that the most efficient vessel for a given species most accurately reflected abundance of that species. Adjustment factors were used for the following species:

Species	Vessel	
	Alaska	Chapman
Yellowfin sole	1.000	0.771
Pacific halibut	1.000	0.678
Alaska plaice	1.000	0.674
Rock sole	1.000	0.640
Arrowtooth flounder	1.000	0.592
Greenland turbot	1.000	0.581

RESULTS

Environment

Water temperature data were collected at every station by both the U.S. and Soviet vessels. Each nation's vessels occupied given stations on different dates and thus temperatures at the same station varied between the two surveys. Also, recording units were not calibrated against each other. However, the temperature pattern shown by the two surveys was generally the same.

During the U.S. survey period (7 June-l August), bottom water temperatures varied from -1.0° to 9.0°C (Fig. 3). Residual cold water (<2.0°C) from winter cooling was found in the central Bering Sea shelf area. Warmest water was found near the Alaska mainland and temperatures were progressively cooler towards the middle shelf, then slightly warmer near the shelf edge.

The Soviet data (15 June-19 August) showed much the same pattern (Fig. 4) although bottom water temperatures ranged from -1.60 to 12.1°C. The same cold water mass was observed in the central shelf area and warm temperatures were recorded along the Alaskan Peninsula as well as the Alaskan mainland.

Surface water temperatures observed from U.S. vessels ranged from 4.5° to 11.6°C (Fig. 5). Most of the surface water over the shelf ranged between 8-9°C. A warmer cell (10°C) appeared in the Pribilof and St. Matthew Islands regions. A cooler cell (6-7°C) extended southeast of Nunivak Island.

Surface water temperatures observed from the U.S.S.R. vessel ranged from 5.6° to 12.8°C (Fig. 6). Their data showed a pattern of 8-9°C surface water over the northwest shelf and 10-11°C water over the southeast shelf and along the Alaska mainland. There appeared to be a colder cell (6-7°C) southwest of Nunivak Island and surface waters were generally colder (7-8°C) along the shelf edge.

Species Encountered

A list of fish species, encountered during each survey, is presented in Table 6. A total of 119 fish species (representing 20 families) were taken: 91 species were recorded on the U.S. vessels and 83 on the Soviet vessel. For purposes of analysis, flathead sole, Hippoglossoides

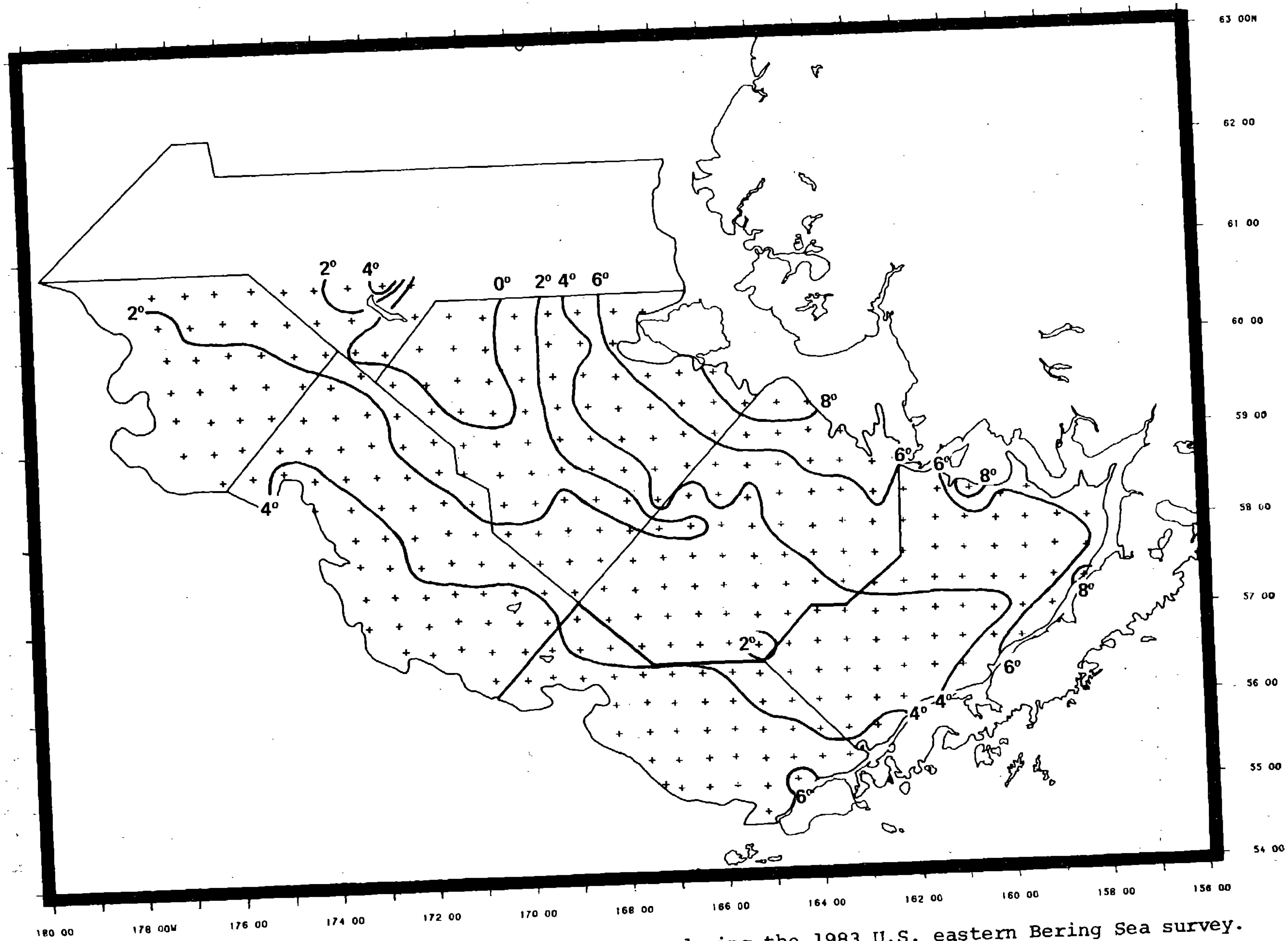

Figure 3.--Distribution of bottom water temperatures during the 1983 U.S. eastern Bering Sea survey.

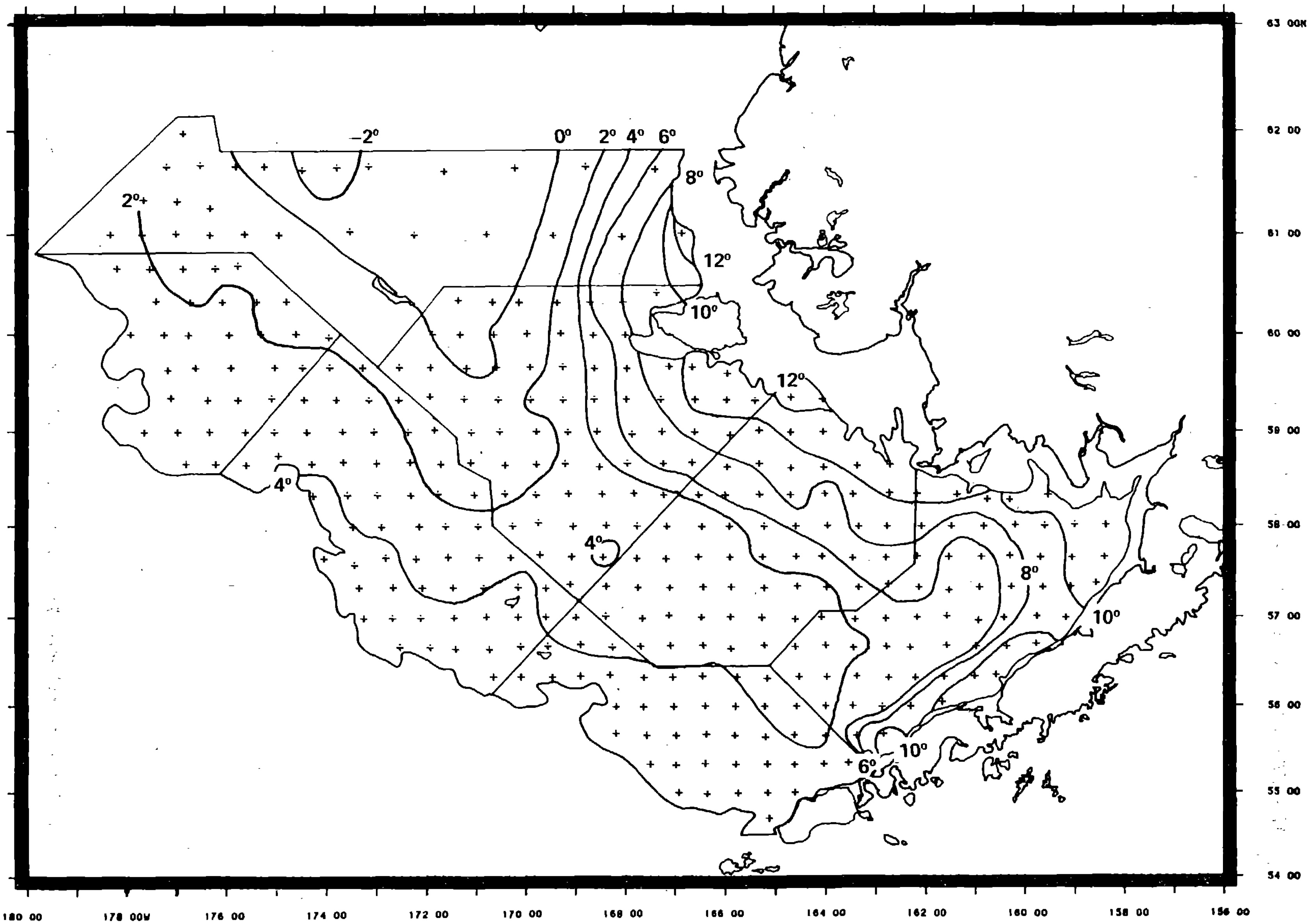

Figure 4.--Distribution of bottom water temperatures during the 1983 U.S.S.R. eastern Bering Sea survey.

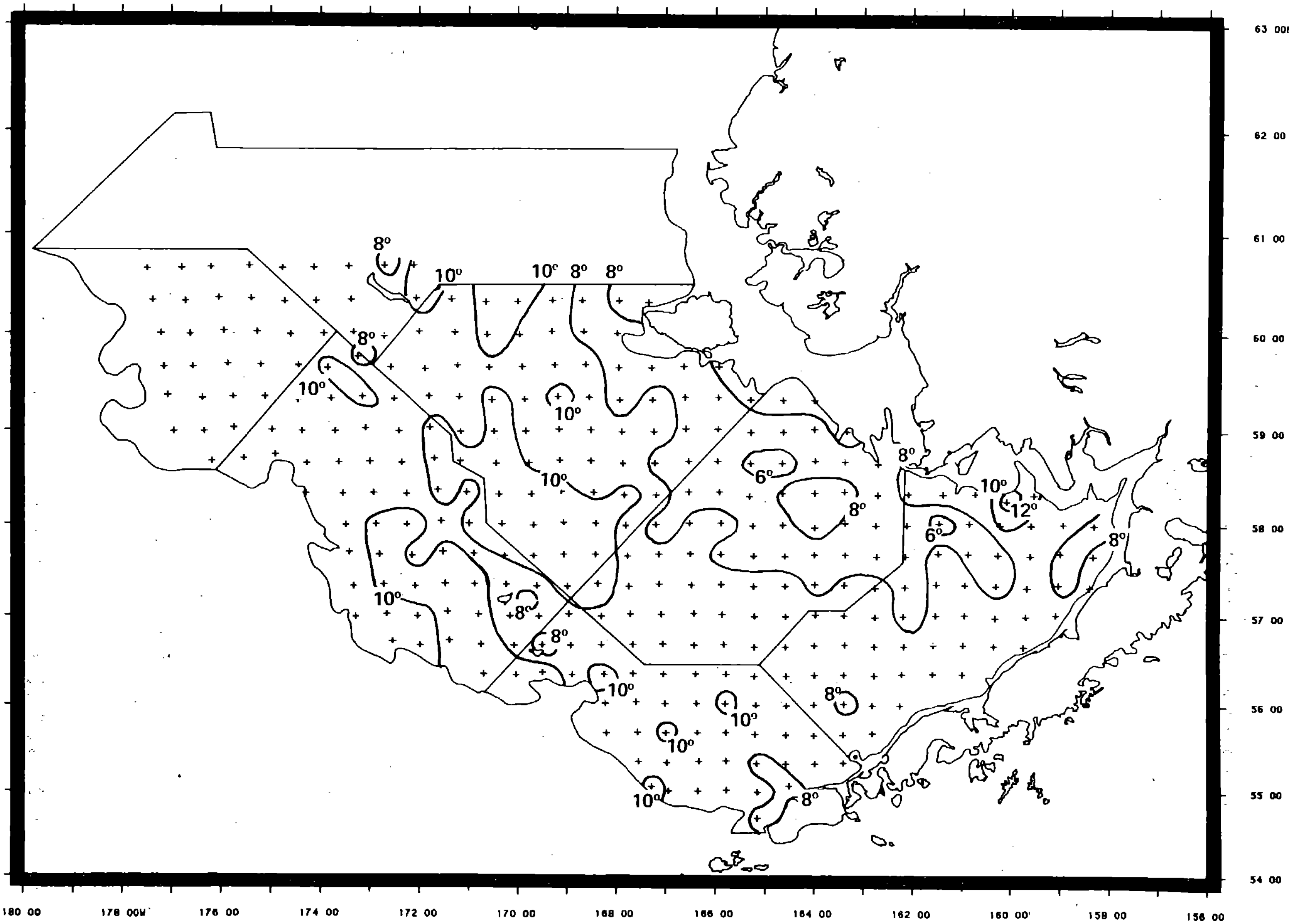

Figure 5.--Distribution of surface water temperatures during the 1983 U.S. eastern Bering Sea survey.

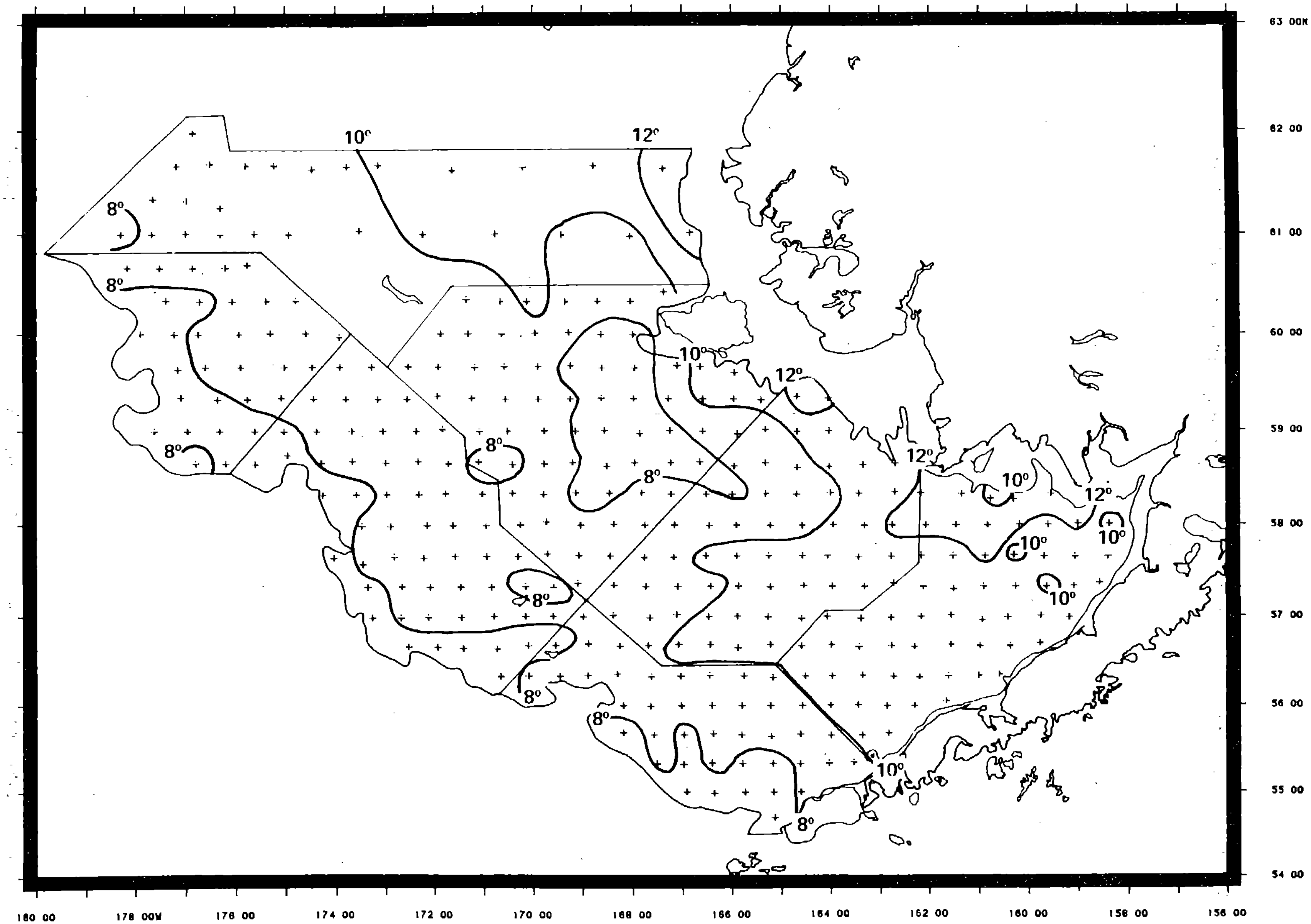

Figure 6.--Distribution of surface water temperatures during the 1983 U.S.S.R. eastern Bering Sea survey.

Table 6.--List of fish species identified during the 1983 U.S. and U.S.S.R. Bering Sea surveys.

Family and species[a]	Common name[a]	Nation U.S.	Nation U.S.S.R.
Squalidae			
Squalus acanthias	Spiny dogfish	X	--
Rajidae			
Bathyraja interrupta[b]	Bering skate	X	--
Bathyraja kincaidi[b]	Sandpaper skate	X	X
Bathyraja rosispinis[b]	Flathead skate	X	--
Bathyraja smirnovi[c]	Golden skate[c]	X	--
Raja sp.	Skate unid.	X	X
Raja aleutica	Aleutian skate	X	--
Raja binoculata	Big skate	X	X
Raja parmifera	Alaska skate	X	X
Raja stellulata	Starry skate	X	X
Salmonidae			
Oncorhynchus keta	Chum salmon	X	X
Oncorhynchus tshawytscha	Chinook salmon	--	X
Clupeidae			
Clupea harengus pallasi	Pacific herring	X	X
Osmeridae			
Osmeridae sp.	Smelt unid.	--	X
Osmerus mordax	Rainbow smelt	X	X
Mallotus villosus	Capelin	X	X
Thaleichthys pacificus	Eulachon	X	X
Gadidae			
Boreogadus saida	Arctic cod	X	X
Eleginus gracilis	Saffron cod	X	X
Gadus macrocephalus	Pacific cod	X	X
Theragra chalcogramma	Walleye pollock	X	X
Zoarcidae			
Lycodes sp.	Eelpout unid.	--	X
Lycodes brevipes	Shortfin eelpout	X	X
Lycodes mucosus	--	X	--
Lycodes palearis	Wattled eelpout	X	X
Lycodes raridens[d]	Sparse toothed lycod[d]	X	X
Lycodes turneri	Polar eelpout	X	--
Scorpaenidae			
Sebastes aleutianus	Rougheye rockfish	X	X
Sebastes alutus	Pacific ocean perch	X	X
Sebastes borealis	Shortraker rockfish	--	X
Sebastes ciliatus	Dusky rockfish	--	X
Sebastes polyspinis	Northern rockfish	X	X

Table 6. (Cont.)

Family and species[a]	Common name[a]	Nation U.S.	Nation U.S.S.R.
Hexagrammidae			
Hexagrammos sp.	Greenling unid.	X	X
Hexagrammos decagrammus	Kelp greenling	X	--
Hexagrammos lagocephalus	Rock greenling	X	--
Hexagrammos octogrammus	Masked greenling	--	X
Hexagrammos stelleri	Whitespotted greenling	X	X
Pleurogrammus monopterygius	Atka mackerel	X	X
Anoplopomatidae			
Anoplopoma fimbria	Sablefish	X	X
Cottidae			
Blepsias bilobus	Crested sculpin	--	X
Cottidae sp.	Sculpin unid.	X	X
Dasycottus setiger	Spinyhead sculpin	X	--
Enophrys lucasi	Leister sculpin	X	--
Gymnocanthus galeatus	Armorhead sculpin	X	X
Gymnocanthus pistilliger[d]	Threaded sculpin[d]	X	--
Gymnocanthus tricuspis	Arctic staghorn sculpin	X	--
Hemilepidotus hemilepidotus	Red Irish lord	X	--
Hemilepidotus jordani	Yellow Irish lord	X	X
Hemilepidotus spinosus	Brown Irish lord	--	X
Hemilepidotus zapus	Longfin Irish lord	--	X
Hemitripterus bolini	Bigmouth sculpin	X	X
Icelus sp.	Sculpin unid.	X	--
Icelus canaliculatus[d]	--	X	--
Icelus spatula	Spatulate sculpin	--	X
Icelus spiniger	Thorny sculpin	X	X
Leptocottus armatus	Pacific staghorn sculpin	--	X
Malacocottus kincaidi	Blackfin sculpin	X	X
Malacocottus zonurus[e]	Darkfin sculpin[e]	X	X
Megalocottus platycephalus	Belligerent sculpin	--	X
Melletes papilio	Butterfly sculpin	X	X
Myoxocephalus sp.	Sculpin unid.	X	X
Myoxocephalus jaok	Plain sculpin	X	X
Myoxocephalus polycanthocephalus	Great sculpin	X	X
Myoxocephalus stelleri[d]	Frog sculpin[f]	--	X
Myoxocephalus verrucosus[d]	Warty sculpin[d]	X	X
Triglops sp.	Sculpin unid.	X	--
Triglops forficata	Scissortail sculpin	X	--
Triglops macellus	Roughspine sculpin	--	X
Triglops pingeli	Ribbed sculpin	X	--
Triglops scepticus	Spectacled sculpin	X	--
Agonidae			
Agonopsis vulsa	Northern spearnose poacher	X	--
Agonidae sp.	Poacher unid.	--	X
Agonus acipenserinus	Sturgeon poacher	X	X
Anoplagonus inermis	Smooth alligatorfish	X	--

Table 6. (Cont.)

Family and species[a]	Common name[a]	Nation U.S.	Nation U.S.S.R.
Aspidophoroides bartoni	Aleutian alligatorfish	X	--
Bathyagonus sp.	Poacher unid.	X	--
Bathyagonus alascanus	Gray starsnout	X	--
Ocella dodecaedron	Bering poacher	X	--
Ocella verrucosa	Warty poacher	X	X
Pallasina barbato	Tubenose poacher	--	X
Sarritor frenatus	Sawback poacher	X	X
Cyclopteridae			
Careproctus sp.	Snailfish unid.	X	--
Careproctus melanurus	Blacktail snailfish	--	X
Careproctus phasma[d]	--	--	X
Careproctus rastrinus[d]	--	X	--
Careproctus scottae[d]	--	X	--
Cyclopteridae sp.	Snailfish unid.	X	X
Eumicrotremus orbis	Pacific spiny lumpsucker	X	X
Liparis sp.	Snailfish unid.	X	X
Liparis bristolense	--	--	X
Liparis dennyi	Marbled snailfish	--	X
Liparis fucensis	Slipskin snailfish	--	X
Liparis pulchellus	Showy snailfish	--	X
Trichodontidae			
Trichodon trichodon	Pacific sandfish	X	X
Bathymasteridae			
Bathymaster signatus	Searcher	X	X
Anarhichadidae			
Anarhichas orientalis	Bering wolffish	X	X
Anarrhichthys ocellatus	Wolf-eel	--	X
Stichaeidae			
Lumpenella longirostris	Longsnout prickleback	X	X
Lumpenus maculatus	Daubed shanny	X	X
Lumpenus sagitta	Snake prickleback	X	X
Lumpenus fabricii	Slender eelblenny	X	--
Poroclinus rothrocki	Whitebarred prickleback	X	--
Zaproridae			
Zaprora silenus	Prowfish	X	X
Ammodytidae			
Ammodytes hexapterus	Pacific sand lance	X	X
Pleuronectidae			
Atheresthes evermanni	Kamchatka flounder	X	--
Atheresthes stomias	Arrowtooth flounder	X	X

Table 6 (Cont.)

Family and species[a]	Common name[a]	Nation U.S.	Nation U.S.S.R.
Glyptocephalus zachirus	Rex sole	X	X
Hippoglossoides elassodon	Flathead sole	X	X
Hippoglossoides robustus	Bering flounder	X	X
Hippoglossus stenolepis	Pacific halibut	X	X
Isopsetta isolepis	Butter sole	X	--
Lepidopsetta bilineata	Rock sole	X	X
Limanda aspera	Yellowfin sole	X	X
Limanda proboscidea	Longhead dab	X	X
Platichthys stellatus	Starry flounder	X	X
Pleuronectidae sp.	Flatfish unid.	X	--
Pleuronectes quadrituberculatus	Alaska plaice	X	X
Psettichthys melanostictus	Sand sole	X	--
Reinhardtius hippoglossoides	Greenland turbot[g]	X	X

a Nomenclature from Robins (1980), unless noted.
b Eschmeyer et al. (1983).
c Shiino (1972).
d Quast and Hall (1972).
e Kessler (in press).
f Ichthyological Society of Japan (1981).
g Market name.

elassodon, and Bering flounder H. robustus, (often confused) were combined and treated as flathead sole. There is a similar problem with arrowtooth flounder, Atheresthes stomias, and Kamchatka flounder, A. evermanni. These have been combined and treated as arrowtooth flounder since a distinction was not made by the scientists aboard the Soviet vessel and the separation may have been inconsistent on the U.S. vessels.

CPUE Estimates

The top 10 species from the U.S. and U.S.S.R. surveys, in order of relative abundance, are included in Table 7. These species comprised 84% of the catch in the U.S. survey area, and 95% of the catch durin the U.S.S.R. survey. Eight of the ten top ranking species were the same in both surveys, but only the top three species appeared in the same order.

The most significant aspect of the rankings is that all of the mean CPUE values from the U.S. survey were greater than those from the Soviet survey, particularly in the case of the flatfish. Estimates from the U.S. survey exceeded those from the U.S.S.R. by 2 l/2 times for yellowfin sole, Limanda aspera, and Alaska plaice, Pleuronectes quadrituberculatus, and by 4 times for rock sole, Lepidopsetta bilineata, and flathead sole. Even though Pacific halibut, Hippoglossus stenolepis, and Pacific herring, Clupea harengus pallasi, appear in the U.S.S.R. survey list, but not in the U.S. summary, these species were actually more abundant in the U.S. survey results (Table 8).

Biomass Estimates

Biomass estimates for principal fish species from the U.S. and U.S.S.R. surveys are given in Table 9. Results from the two surveys were supportive in showing that walleye pollock, yellowfin sole, and Pacific

Table 7.--Rank order of abundance of the ten most abundant species of fish taken during the 1983 U.S. and U.S.S.R. eastern Bering Sea surveys, all six subareas cabined.

Nation and rank	Species	Mean CPUE kg/ha[a]	Proportion of total CPUE[b]	Cumulative proportion[c]
United States				
1	Walleye pollock	129.17	0.364	0.364
2	Yellowfin sole	90.57	0.255	0.619
3	Pacific cod	24.55	0.069	0.688
4	Rock sole	21.23	0.060	0.748
5	Alaska plaice	14.17	0.040	0.788
6	Flathead sole	6.10	0.017	0.805
7	Skates	3.65	0.010	0.815
8	*Myoxocephalus* sp.	3.35	0.009	0.825
9	Arrowtooth flounder	3.17	0.009	0.834
10	Eelpouts	2.27	0.006	0.840
U.S.S.R.				
1	Walleye pollock	90.19	0.547	0.547
2	Yellowfin sole	34.24	0.207	0.754
3	Pacific cod	16.23	0.098	0.852
4	Alaska plaice	5.92	0.036	0.888
5	Rock sole	4.97	0.009	0.918
6	Flathead sole	1.47	0.008	0.927
7	Pacific halibut	1.33	0.006	0.935
8	Pacific herring	0.96	0.006	0.941
9	*Myoxocephalus* sp.	0.94	0.006	0.947
10	Skates	0.86	0.005	0.952

[a] Total effort: U.S. = 1376.1 ha, U.S.S.R. = 3110.0 ha.
[b] Proportion of total CPUE, fish only. Total CPUE: U.S. = 354.94 kg/ha, U.S.S.R. = 165.01 kg/ha.
[c] Rounding accounts for minor discrepancies between sum of proportions for individual species and cumulative proportions.

Table 8.--Mean catch-per-unit effort (kg/ha) values for major species, by subarea, from 1983 U.S. and U.S.S.R. eastern Bering Sea surveys.

Species	U.S. survey 1	2	3	4	6	7	Total	U.S.S.R. survey 1	2	3	4	6	7	Total
Walleye pollock	131.5	195.2	99.8	69.5	63.9	228.2	129.2	49.4	169.5	146.3	30.2	24.2	171.7	90.2
Pacific cod	33.0	13.1	23.8	31.6	17.7	24.4	24.6	22.0	7.6	17.7	11.6	14.5	23.0	16.2
Sablefish	--	1.0	--	--	--	1.4	0.4	--	0.4	--	--	--	<0.1	0.1
Pacific herring	3.4	0.2	<0.1	2.2	0.1	4.4	1.9	0.6	0.9	<0.1	1.7	2.1	<0.1	1.0
Yellowfin sole	184.5	27.3	<0.1	107.8	164.6	5.9	90.6	59.3	4.4	--	34.1	85.7	0.5	34.2
Rock sole	73.7	8.1	0.1	9.2	19.1	8.3	21.2	18.9	1.0	0.1	1.1	5.3	1.3	5.0
Flathead sole	6.8	12.1	10.2	1.7	2.8	6.8	6.1	1.6	2.5	2.1	0.3	1.2	1.7	1.5
Alaska plaice	8.6	4.3	0.1	30.0	27.2	4.3	14.2	4.7	0.6	<0.1	11.9	12.7	0.9	5.9
Greenland turbot	<0.1	0.3	3.4	0.1	<0.1	1.5	0.7	<0.1	<0.1	1.1	0.1	<0.1	0.4	0.2
Arrowtooth flounder	0.7	11.9	2.3	0.2	0.6	5.6	3.2	0.3	1.8	0.4	0.1	0.2	0.8	0.5
Pacific halibut	4.3	3.3	0.2	1.7	1.5	1.8	2.2	3.2	1.4	0.1	0.6	1.0	1.3	1.3
Total trawls	58	43	28	68	57	56	310	59	42	32	68	57	57	315
Total species [a]	92	110	97	103	122	119	217	46	37	28	46	44	43	78
Total effort (ha)	263.2	184.6	123.5	303.8	254.9	245.9	1376.1	566.4	422.5	338.2	664.3	560.1	558.5	3110.0

[a] May be less than number of species encountered, due to rank grouping.

Table 9.--Estimated biomass (metric tons) of major species, by subarea, from the 1983 U.S. and U.S.S.R. eastern Bering Sea surveys.

Species	Nation	Subarea 1	2	3	4	6	7	Total	95% Confidence interval
Walleye pollock	U.S.	1,036,213	1,178,353	480,697	633,552	527,089	1,859,312	5,715,216	(4,717,717- 6,712,715)
	U.S.S.R.	389,417	1,023,082	705,088	275,456	199,118	1,399,037	3,991,198	(3,176,607- 4,805,790)
Pacific cod	U.S.	260,256	79,109	114,574	288,108	145,943	198,425	1,086,415	(849,749- 1,323,082)
	U.S.S.R.	173,781	46,002	85,129	106,190	119,197	187,684	717,981	(610,896- 825,066)
Sablefish	U.S.	--	6,190	--	--	--	11,775	17,966	(0- 39,836)
	U.S.S.R.	--	2,436	--	--	--	245	2,680	(1,117- 4,244)
Pacific herring	U.S.	27,033	1,175	54	20,500	1,193	35,860	85,814	(25,931- 145,697)
	U.S.S.R.	4,564	5,503	1	15,206	17,207	119	42,600	(13,571- 71,631)
Yellowfin sole[a]	U.S.	1,454,630	164,482	39	983,489	1,356,683	47,991	4,007,315	(3,512,516- 4,502,114)
	U.S.S.R.	467,065	26,377	--	310,956	706,474	4,215	1,515,087	(1,290,181- 1,739,356)
Rock sole[a]	U.S.	581,305	48,858	349	83,721	157,326	67,827	939,386	(729,678- 1,149,094)
	U.S.S.R.	148,656	5,950	374	10,272	44,012	10,499	219,764	(159,051- 280,477)
Flathead sole	U.S.	53,245	73,085	49,236	15,539	23,301	55,522	269,927	(204,775- 335,079)
	U.S.S.R.	12,951	15,389	10,072	2,463	9,925	14,109	64,910	(51,159- 78,662)
Alaska plaice[a]	U.S.	68,064	25,732	278	273,393	224,530	35,020	627,016	(515,366- 738,667)
	U.S.S.R.	36,862	3,856	31	108,285	104,987	7,737	261,759	(210,234- 322,283)
Greenland turbot[a]	U.S.	13	1,985	16,471	1,099	211	12,199	31,980	(24,249- 39,711)
	U.S.S.R.	23	160	5,456	535	11	3,545	9,730	(7,361- 12,099)
Arrowtooth flounder[a]	U.S.	5,513	71,672	11,014	2,163	4,590	45,363	140,316	(118,689- 161,943)
	U.S.S.R.	2,539	10,781	1,774	546	1,593	6,293	23,527	(19,582- 27,471)
Pacific halibut[a]	U.S.	33,956	20,164	1,196	15,211	12,720	14,497	97,748	(74,100- 121,396)
	U.S.S.R.	25,082	8,359	319	5,550	8,624	10,940	58,874	(45,026- 72,721)
Other fish	U.S.	69,109	116,408	61,430	170,041	89,756	107,633	614,377	(52,340- 705,353)
	U.S.S.R.	34,638	31,359	5,095	37,099	28,488	26,726	163,404	(12,709- 199,719)
Total (all species)	U.S.	3,958,454	2,004,429	871,929	2,944,535	2,976,195	2,948,855	15,704,407	(14,488,836-16,919,978)
	U.S.S.R.	1,447,644	1,179,860	814,587	893,492	1,283,717	1,283,717	7,301,722	(6,420,993- 8,182,451)

[a] U.S. values standardized to research vessel Alaska.

cod were the most abundant species in the survey area. However/in almost all cases, the 95% confidence intervals showed that the U.S. and U.S.S.R. biomass estimates were significantly different. There was an overlap in the confidence intervals only for walleye pollock and sablefish, Anoplopoma fimbria, indicating that the two estimates were not significantly different. For all major species, U.S. biomass estimates ranged from approximately 1.5 to 6.7 times larger than corresponding U.S.S.R. biomass estimates, and as noted with CPUE estimates, differences were particularly large for the flatfishes.

Table 10 shows the distribution of biomass estimates, by subarea, for the two surveys. Five of the eleven major species were concentrated on the outer shelf: walleye pollock; sablefish; flathead sole; Greenland turbot, Reinhardtius hippoglossoides; and arrowtooth flounder. The species showing strong affinity for inner shelf waters were yellowfin sole, Alaska plaice, rock sole, and to a lesser degree, Pacific cod and Pacific halibut. For these species, with the exception of sablefish, the biomass distributions among regions and subareas were similar for the U.S. and U.S.S.R. surveys. Roth surveys showed that the distribution of sablefish was limited to the outer shelf but the subarea showing the highest abundance differed between the surveys. Pacific herring was the one species which showed markedly different biomass distributions. The U.S. survey data showed a more even distribution of herring between the inner and outer shelf regions, while the U.S.S.R. data showed a high percentage of biomass (87%) in the inner shelf region. The assumption is that the semipelagic nature of Pacific herring makes it more vulnerable to the higher opening U.S.S.R. trawl, yielding more accurate distribution information. However, the overall biomass estimate from the U.S. survey

Table 10.--Percent of estimated biomass (metric tons) of major species, by subarea, from the 1983 U.S. and U.S.S.R. eastern Bering Sea survey.

		Subarea					
		Outer shelf			Inner shelf		
Species	Nation	3	7	2	4	6	1
Walleye pollock	U.S.	8.4	32.5	20.6	11.1	9.2	18.1
	U.S.S.R.	17.7	35.1	25.6	6.9	5.0	9.8
Pacific cod	U.S.	10.5	18.3	7.3	26.5	13.4	24.0
	U.S.S.R.	11.9	26.1	6.4	14.8	16.6	24.2
Sablefish	U.S.	--	65.5	34.5	--	--	--
	U.S.S.R.	--	9.1	90.9	--	--	--
Pacific herring	U.S.	<0.1	41.8	1.4	23.9	1.4	31.5
	U.S.S.R.	<0.1	0.3	12.9	35.7	40.4	10.7
Yellowfin sole	U.S.	<0.1	1.2	4.1	24.5	33.9	36.3
	U.S.S.R.	--	0.3	1.7	20.5	46.6	30.8
Rock sole	U.S.	<0.1	7.2	5.2	8.9	16.7	61.9
	U.S.S.R.	0.2	4.8	2.7	4.7	20.0	67.6
Flathead sole	U.S.	18.2	20.6	27.1	5.8	8.6	19.7
	U.S.S.R.	15.5	21.7	23.7	3.8	15.3	20.0
Alaska plaice	U.S.	<0.1	5.6	4.1	43.6	35.8	10.9
	U.S.S.R.	<0.1	3.0	1.5	41.4	40.1	14.1
Greenland turbot	U.S.	51.5	38.1	6.2	3.4	0.7	<0.1
	U.S.S.R.	56.1	36.4	1.6	5.5	0.1	0.2
Arrowtooth flounder	U.S.	7.8	32.3	51.1	1.5	3.3	3.9
	U.S.S.R.	7.5	26.7	45.8	2.3	6.8	10.8
Pacific halibut	U.S.	1.2	14.8	20.6	15.6	13.0	34.7
	U.S.S.R.	0.5	18.6	14.2	9.4	14.6	42.6

was approximately twice that from the U.S.S.R. survey. These results are difficult to explain; the differences may arise from the schooling behavior and patchy distribution of herring rather than gear variations.

Population estimates for the major species are summarized in Table 11. Again, the U.S. estimates are greater than the U.S.S.R. values except for walleye pollock. As will be shown later, by length frequency data, the reason for this is that the U.S.S.R. vessels sampled greater numbers of small (10-20 cm) pollock than the U.S. vessels.

Size Composition

Eight species of fish had length data collected on both the U.S. and U.S.S.R. vessels. Sablefish, Greenland turbot, and arrowtooth flounder were measured only on the U.S. vessels and therefore are not included here. Figures 7-14 compare population estimates, by length, from the two surveys. The smaller Soviet population estimates are reflected in these figures. The mean lengths from the Soviet catches were larger than those from the U.S. survey, with the exception of walleye pollock (Fig. 7) and Pacific herring (Fig. 9). The smaller mean length of pollock from the U.S.S.R. survey resulted from a higher proportion of 10-35 cm fish in their catches than from U.S. survey catches. In the case of Pacific herring, U.S. vessels took a higher proportion of larger fish. For the remaining species, higher mean lengths from the U.S.S.R. survey resulted from a lower proportion of juvenile fish, <20 cm, in the catches.

DISCUSSION

The 1983 survey was the second year of joint Bering Sea fisheries research with the Soviet Union, and the first year that vessels from the two nations sampled the same survey area in the eastern Berin Sea. The

Table 11.--Population estimates for major species, by subarea, from 1983 U.S. and U.S.S.R. eastern Bering Sea surveys (in millions of fish).

Species	Nation	Subarea 1	2	3	4	6	7	Total	95% Confidence interval
Walleye pollock	U.S.	1,498.2	1,927.2	1,735.6	2,727.1	1,018.4	5,052.3	13,958.7	(11,777.1-16,140.3)
	U.S.S.R.	1,157.8	1,777.9	3,013.7	2,391.7	1,091.9	4,715.5	14,148.4	(10,701.1-17,595.8)
Pacific cod	U.S.	180.8	29.1	34.2	276.0	77.4	73.0	670.5	(515.1- 825.9)
	U.S.S.R.	96.9	15.3	26.3	53.6	48.5	75.0	315.7	(263.0- 368.5)
Sablefish	U.S.	--	5.6	--	--	--	3.6	9.1	(2.0- 161.2)
	U.S.S.R.	--	2.0	--	--	--	0.2	2.2	(0.9- 3.6)
Pacific herring	U.S.	126.2	5.6	0.2	116.6	7.5	185.7	441.7	(134.1- 749.4)
	U.S.S.R.	44.4	20.6	<0.1	109.4	98.9	0.5	273.9	(99.0- 448.8)
Yellowfin sole[a]	U.S.	7,139.1	661.9	0.2	4,241.9	7,078.3	171.1	19,292.5	(16,705.4-21,879.4)
	U.S.S.R.	2,116.9	78.9	--	1,178.9	3,143.9	11.2	6,529.8	(5,477.9- 7,581.7)
Rock sole[a]	U.S.	3,038.7	197.9	0.8	628.1	877.5	199.4	4,942.3	(3,926.5- 5,958.2)
	U.S.S.R.	576.9	24.2	0.6	27.6	161.0	29.0	819.2	(614.1- 1,024.4)
Flathead sole	U.S.	243.8	447.7	189.6	138.5	168.0	285.4	1,473.1	(1,252.5- 1,693.7)
	U.S.S.R.	49.3	66.2	32.7	8.2	44.4	42.0	242.7	(194.5- 291.0)
Alaska plaice[a]	U.S.	135.6	47.9	0.3	548.6	455.5	42.4	1,230.2	(1,018.4- 1,442.0)
	U.S.S.R.	61.3	4.3	<0.1	186.6	195.9	8.5	456.6	(355.0- 558.1)
Greenland turbot[a]	U.S.	<0.1	0.5	34.1	3.1	0.3	20.6	58.6	(43.6- 73.6)
	U.S.S.R.	<0.1	<0.1	8.9	0.7	<0.1	4.6	14.3	(10.9- 17.7)
Arrowtooth flounder[a]	U.S.	19.7	314.1	18.6	13.9	32.0	193.3	591.6	(490.0- 693.3)
	U.S.S.R.	7.8	27.6	2.6	1.3	3.6	16.7	59.6	(48.6- 70.5)
Pacific halibut[a]	U.S.	17.1	5.6	0.4	10.9	5.2	9.5	48.7	(34.6- 62.9)
	U.S.S.R.	8.9	2.3	0.1	2.5	3.2	6.8	23.7	(14.1- 33.4)

[a] U.S. values standardized to research vessel *Alaska*.

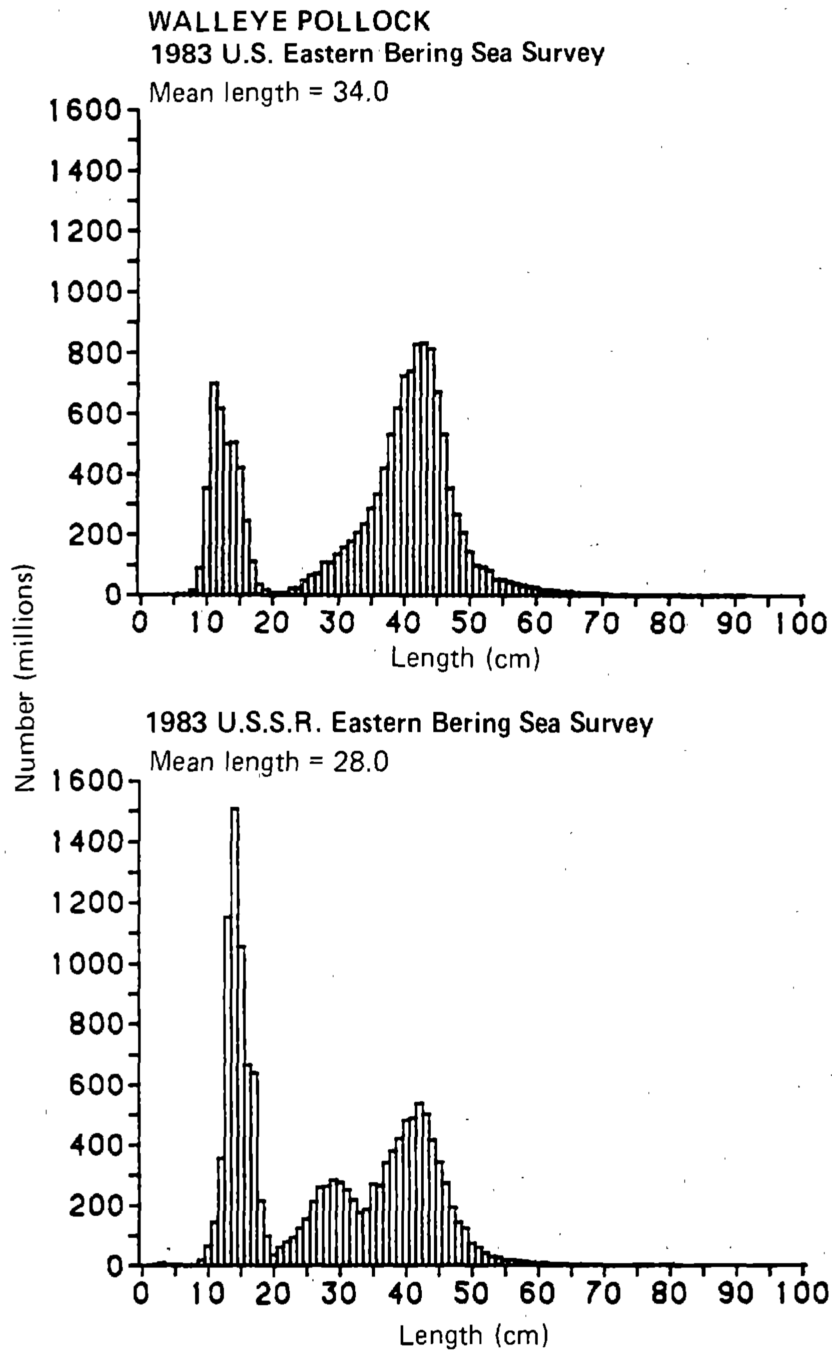

Figure 7.--Length composition of walleye pollock sampled by U.S. and U.S.S.R. research vessels during the 1983 eastern Bering Sea surveys.

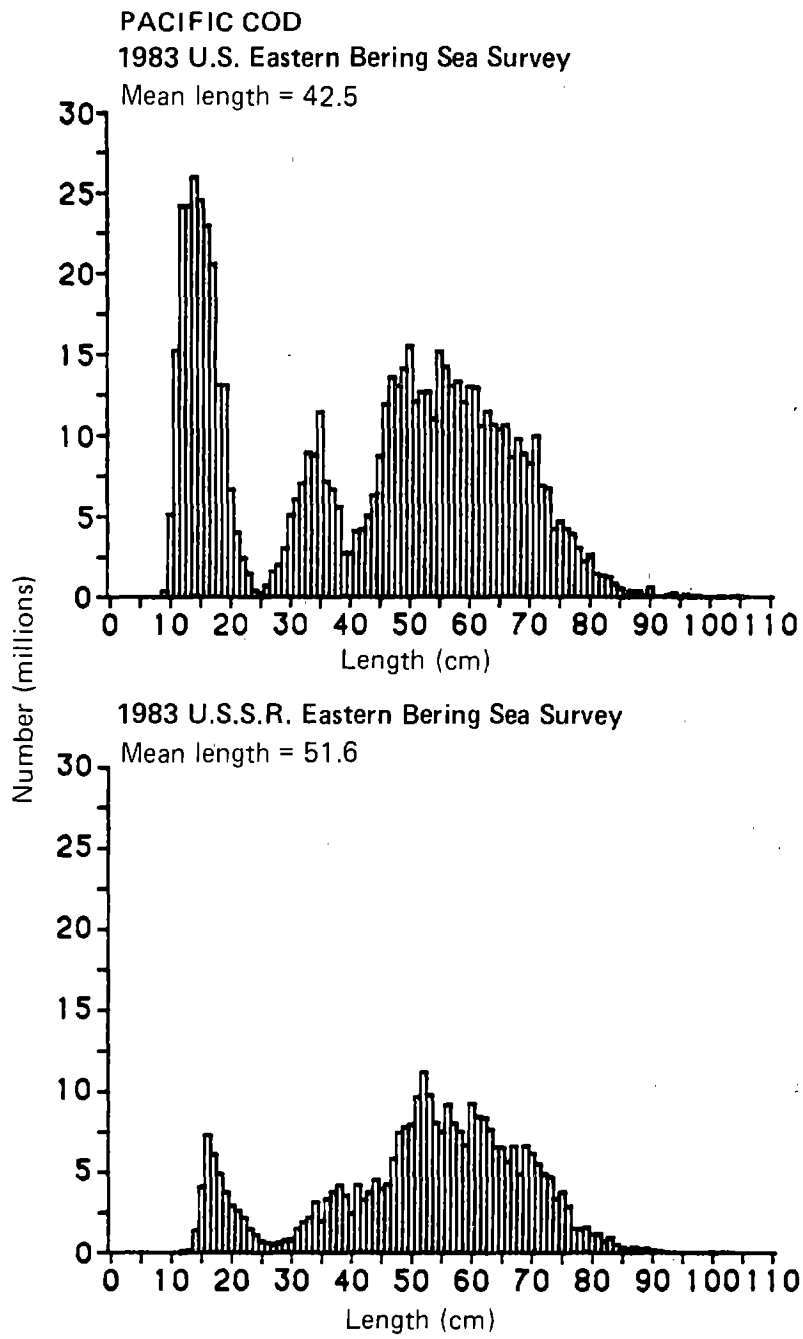

Figure 8. --Length composition of Pacific cod sampled by U.S. and U.S.S.R. research vessels during the 1983 eastern Bering Sea surveys.

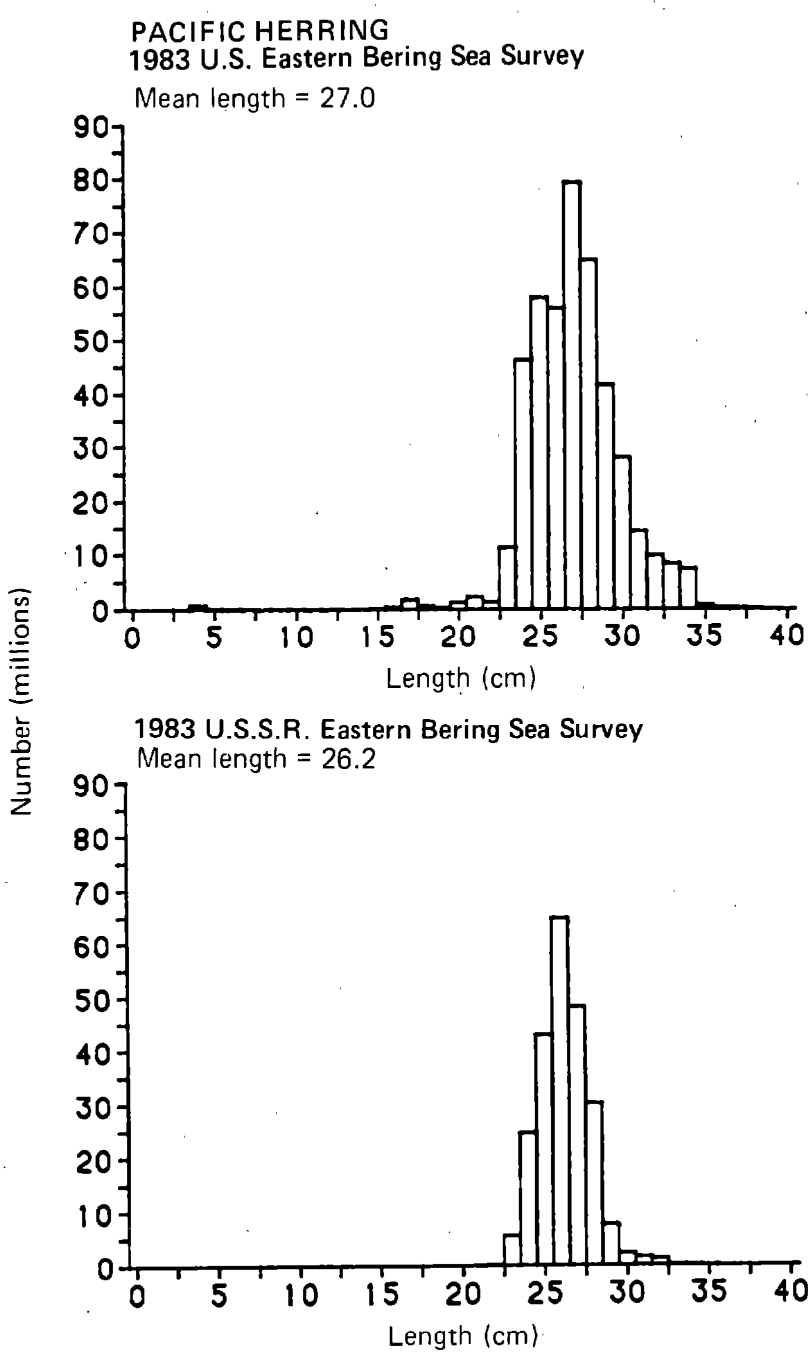

Figure 9.--Length composition of Pacific herring sampled by U.S. and U.S.S.R. research vessels during the 1983 eastern Bering Sea surveys.

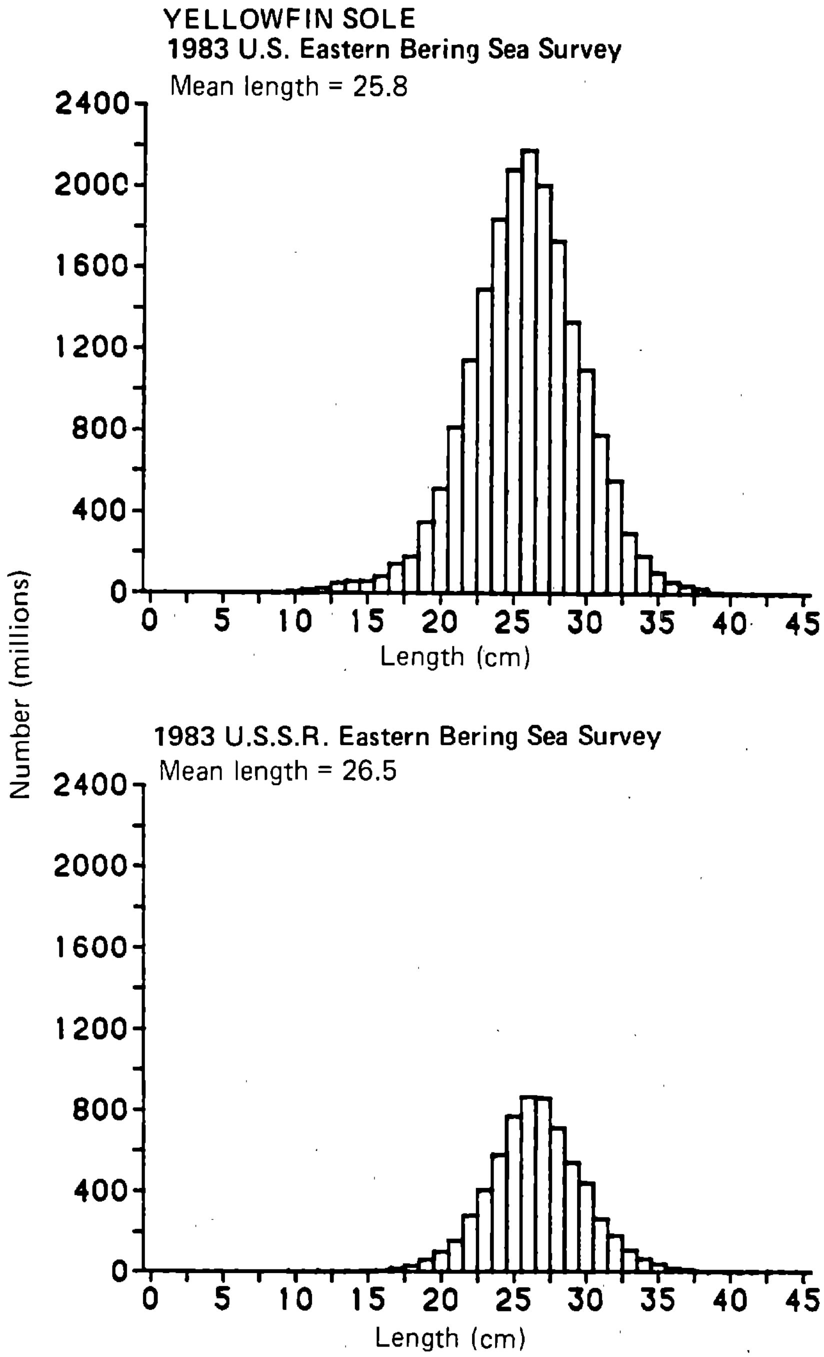

Figure 10.--Length composition of yellowfin sole sampled by U.S. and U.S.S.R. research vessels during the 1983 eastern Bering Sea surveys.

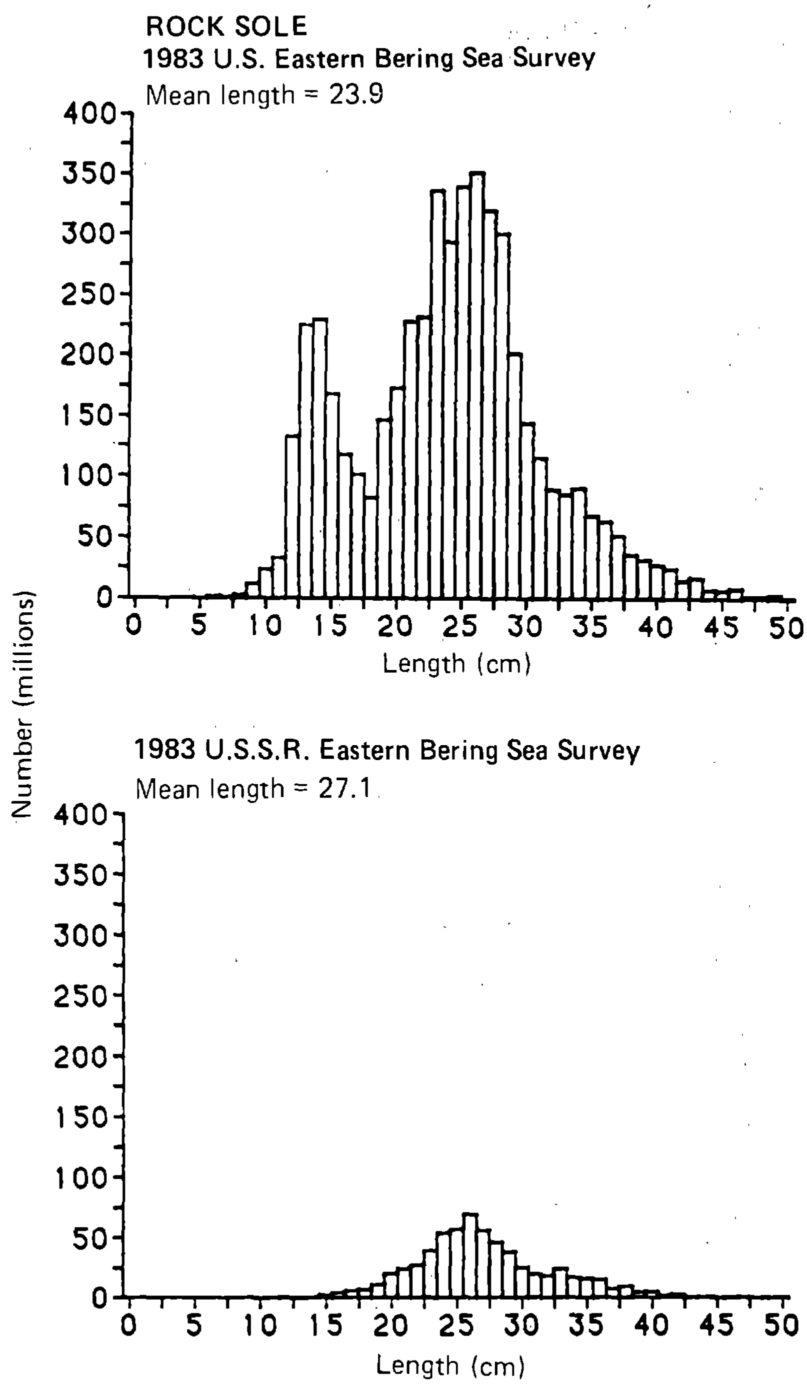

Figure 11 .--Length composition of rock sole sampled by U.S. and U.S.S.R. research vessels during the 1983 eastern Bering Sea surveys.

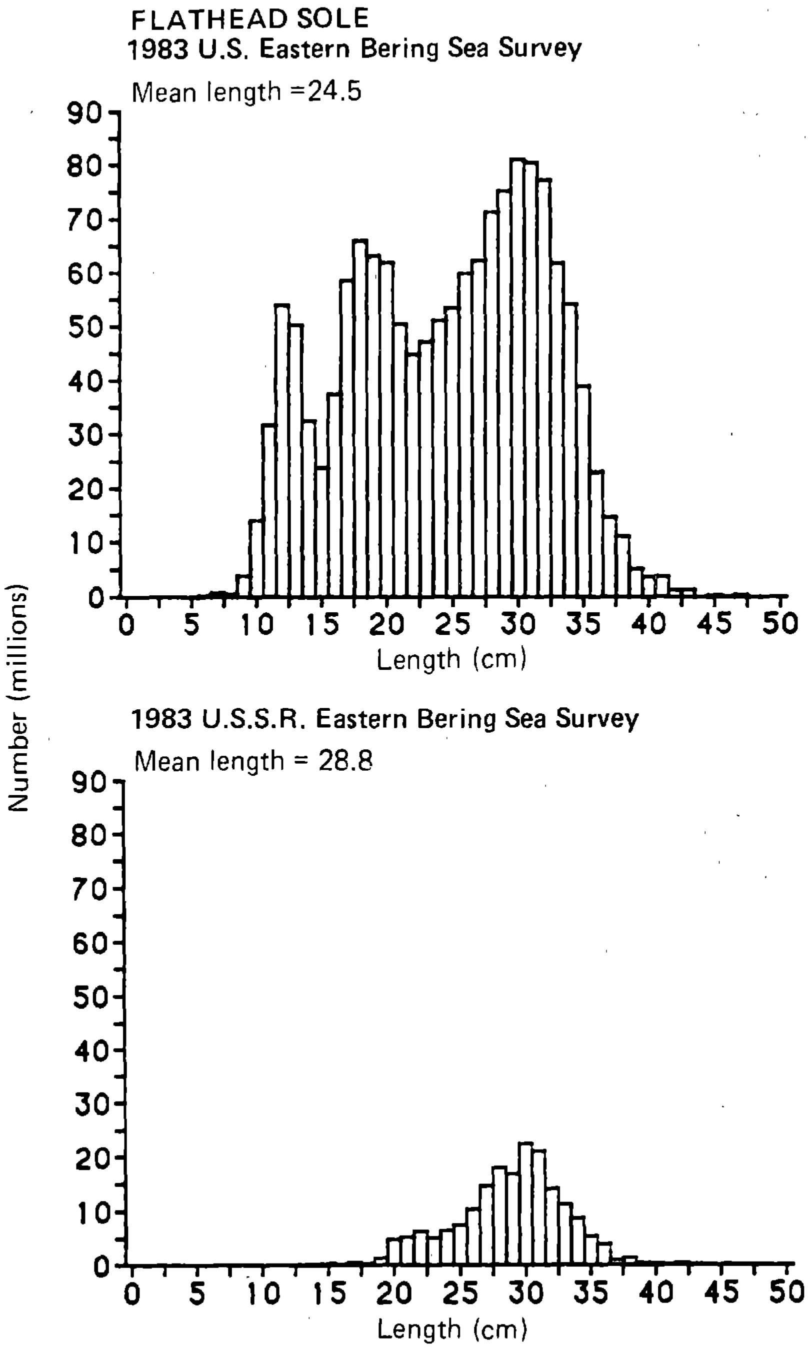

Figure 12.--Length composition of flathead sole sampled by U.S. and U.S.S.R. research vessels during the 1983 eastern Bering Sea surveys.

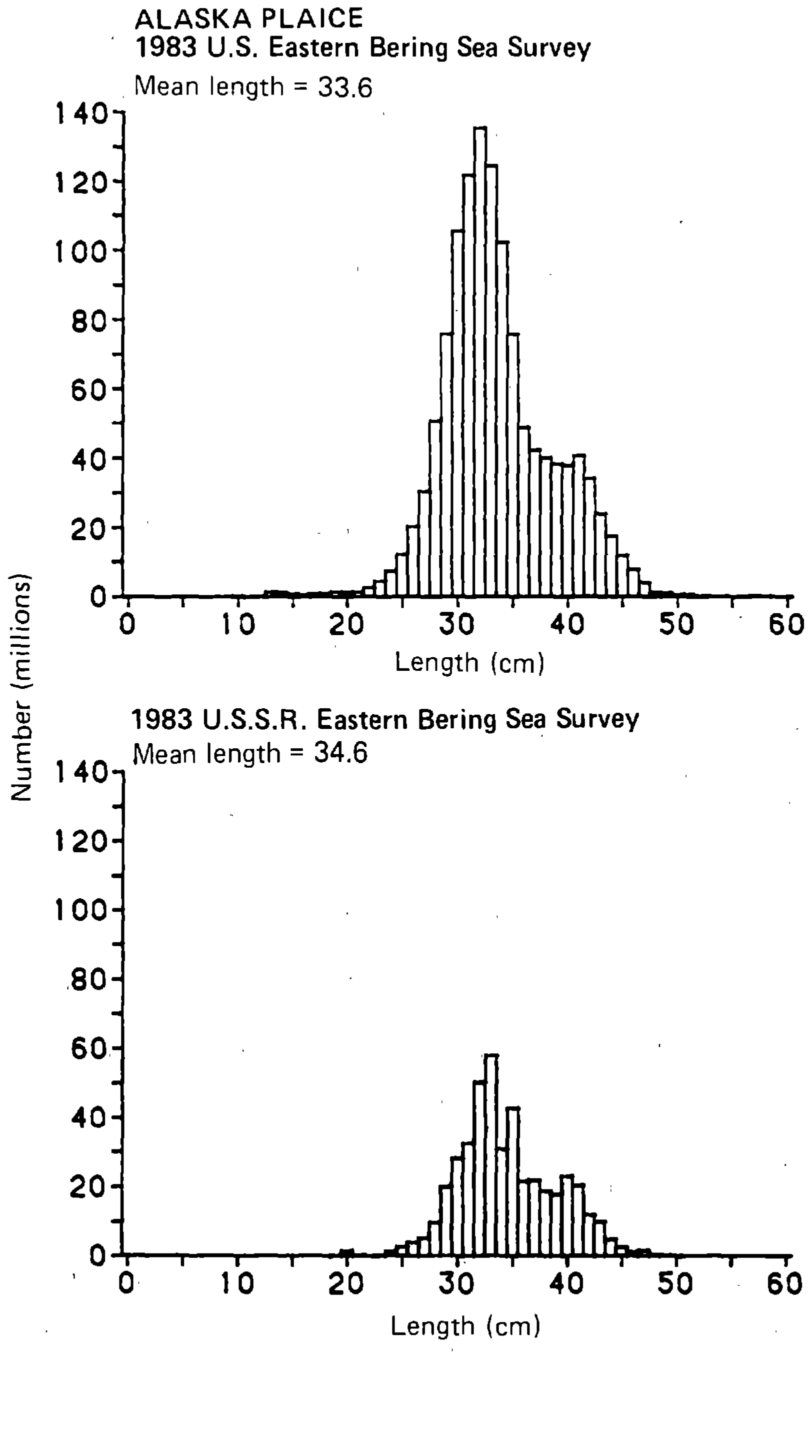

Figure 13. --Length composition of Alaska plaice sampled by U.S. and U.S.S.R. research vessels during the 1983 eastern Bering Sea surveys.

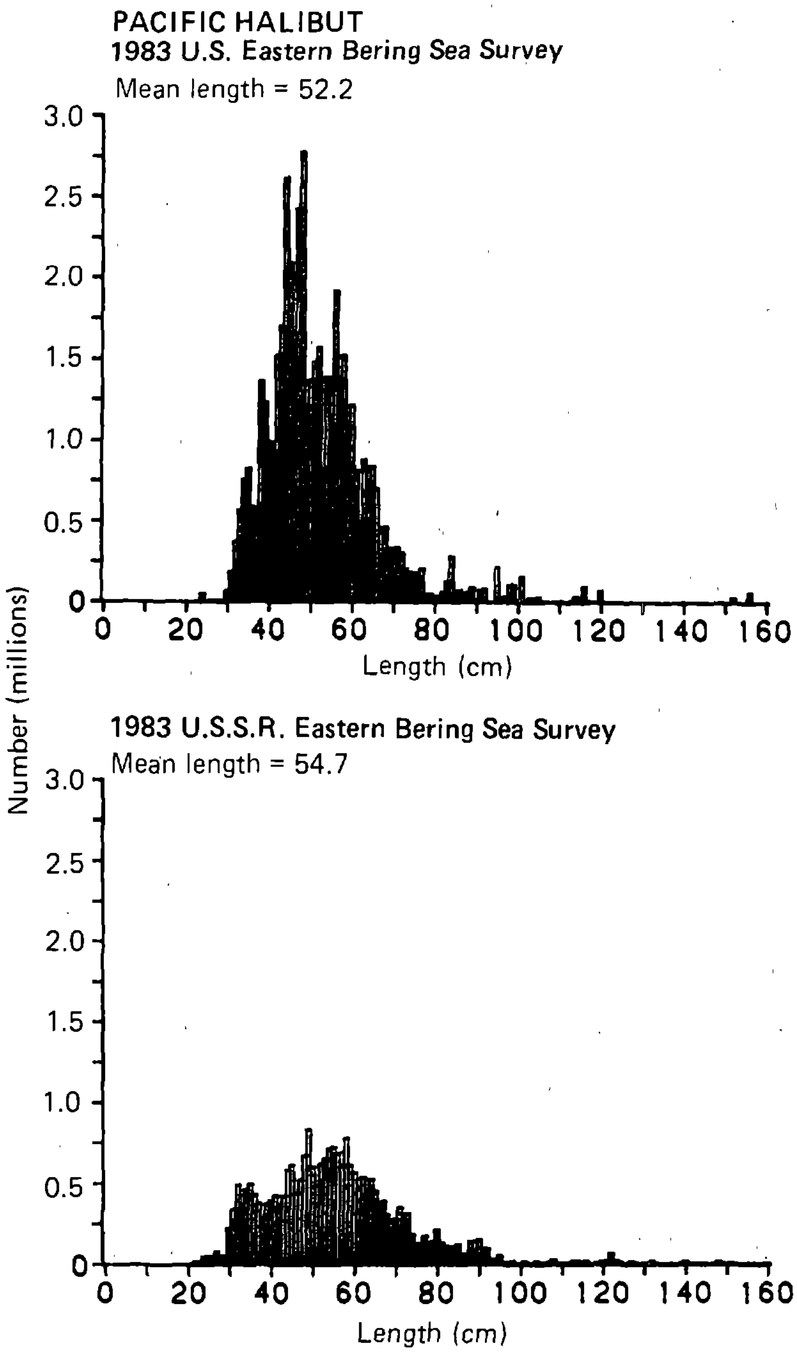

Figure 14. --Length composition of Pacific halibut sampled by U.S. and U.S.S.R. research vessels during the 1983 eastern Bering Sea surveys.

focus of this report was to determine if the combined survey information afforded better groundfish assessment of this region.

Survey design was fairly straightforward, following a long established U.S. grid pattern. Vessel size and gear differences were the most dissimilar survey characteristics although variations in methods of processing catches may be an important factor. The U.S.S.R. vessel was 2-2.5 times larger than the U.S. vessels and generated 2-4 times the horsepower. However; U.S.S.R. abundance estimates were much lower than those from the United States, indicating that trawls and trawl rigging were the primary factors *that may have accounted for the differences between U.S. and U.S.S.R. estimates. During the Soviet survey, roller gear was used but the incidences were not documented, most likely due to poor observer training. Records show that the use of roller gear results in lower catch rates for bottom tending species such as flatfish and a generally lower proportion of small fish, when compared to catches from trawls without roller gear (Wakabayashi et al. 1985). The assumption is that the trawl passes over many bottom dwelling fish while others may have the ability to swim under the footropes, thus avoiding the trawl. In the case of walleye pollock, Traynor and Nelson (1985) found that a high proportion of smaller individuals occupy midwater layers. This accounts for the higher proportion of 10-35 cm pollock in the U.S.S.R. data, collected with a higher opening trawl (6.0 m).

Sampling procedures can also cause variations in biomass and population estimates. The U.S.S.R. vessel often handled large catches which necessitated alteration of the sampling procedures. Some U.S.S.R. catch weights were based on visual estimates or extrapolation from factory weights, while U.S. catches and subsamples were weighed in a consistent manner.

From the examination of the two data bases, it is concluded that differences preclude combining the results for a more comprehensive assessment of eastern Bering Sea groundfish in 1983. Fishing power coefficients could be developed to account for differences in catch rates for individual species, but these would not be valid unless they were derived by taking into account the use of roller gear on the Soviet trawl. To produce meaningful results from joint U.S.-U.S.S.R. surveys, standardized methods of sampling, processing catches and collecting biological data should be followed. Also, comparative trawl efforts should be organized to develop relative fishing-power estimates.

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