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Attachment 6

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*FOR THE 8TH ANNUAL CONFERENCE OF THE PARTIES TO THE
CONVENTION ON THE CONSERVATION AND MANAGEMENT OF
POLLOCK RESOURCES IN THE CENTRAL BERING SEA*

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Federal Committee on Fisheries of Russian Federation

**HYDROACOUSTIC AND BOTTOM TRAWL SURVEYS OF THE BERING
SEA WALLEYE POLLOCK IN OCTOBER-NOVEMBER 2002**

(document submitted for VIII Bering Sea Pollock Conference, Portland, 2003)

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The demersal component of the stock is usually assessed during bottom trawl surveys while pelagic component is studied using acoustic surveys (Karp and Wallers, 1994). It was stated by numerous surveys that usually demersal orientation is more common for older fish, and younger fish are more distributed in midwater. Simultaneously conducted bottom trawl and acoustic surveys could give new data to estimate the stock and to compare different ages vertical distribution.

The surveys were conducted simultaneously in the same area of the North-West part of Bering Sea near cape Navarin from October 28 to November 4, 2002. Acoustic data were collected in the whole water column using EY500 Simrad echosounder on the board of Japanese trawler KAYE-MARU №28.

The trackline consisted of 448 nautical miles (Fig.1).

The following a specialized complex of the equipment and the software was used for the echo survey:

- echo sounder EY500 Simrad (38 kHz) with single beam antenna in the towed body;
- PC, used as the block of management and monitor of echo sounder;
- GPS receiver of firm Trimble Navigation (USA), connected to the computer of the echo sounder and automatically determining coordinates of a vessel, which are registered together with acoustic data;
- magneto-optical drive Fujitsu FMO-1300WS2 for recording echo signals from the computer, which was used as the store of the information;
- echo processing system EP500 Simrad for reproducing and processing of the recorded echo signals.
- colour printer DeskJet HP850C (Hewlett Packard).

Complex allows to automate completely the collection of data during echo survey, providing record of primary data (as echo signal from an output of echo sounder) for their subsequent storage and processing. Other important peculiarity of a complex is an automatic determination of coordinates of a vessel with rather high precision of GPS system, registration of echo signals and coordinates simultaneously. It allows to calculate plots of distribution of measured parameters, to locate significant interesting records.

Nowadays advanced direction in hydroacoustics are methods and equipment of a quantitative estimation of fish schoolings. Created methods (Manual of hydroacoustic surveying, 1984) are well fulfilled and are widely used for biomass estimation of fish schooling and its distribution at realization echo survey in process of fishery researches with the use of echo sounders and echo integrators.

The method of realization of hydroacoustic surveys includes the following standard stages:

- installation of the equipment on a vessel and checking its functioning;
- calibration of the equipment with the use of standard copper sphere;
- choice of transects and parameters of echo survey (speed of a vessel, length of transect lines, place of control trawling, elementary sampling distance unit (ESDU) and etc.);
- choice of working parameters of the equipment during survey;
- directly registration and record of echo sign;
- data processing of survey, plotting of the echo integration results, estimation of the biomass with a confidence intervals.

The antenna of echo sounders was towed from the left board on a course of a vessel on depth about 2.5 m, in order to exclude influence of reflections of a echo sounder signals from the frame of a vessel and superficial of sound-scattering layers (air bubbles). Proceeding from the methodical recommendations of operation of the echo sounders and design peculiarities of a vessel, the speed of a movement was chosen 4.5 - 6 knots.

The choice of a transects was determined in view of results of the previous surveys, and also with necessity of more detailed surveying of chosen region. Transects of hydroacoustic survey crossed depths about 250 meters. The preliminary tests of echo sounder EY500 have show that the level of a signal-to-noise-ratio at duration of a pulse 1 msec (Medium) on such depths has appeared insufficient. Therefore duration of a pulse 3 msec (Long) with a narrow band was chosen. The record of echo signals was conducted during the day-and-night time with breaks, necessary for conduction control trawls.

Control trawls were carried out in places with high density of fish schooling and at change of character of their registration, where it was possible.

Biomass calculation W was computed according to a «Manual of hydroacoustic surveying» (1984) and instruction for use of echo processing system EP-500.

The technology of processing of acoustic data based on a principle of detailed stratification of region with the account length category of pollock stocks and another species. In a basis of such approach lay the following parcels:

- the acoustic image of a schooling rather adequately displays spatial distribution and behaviour of objects on a certain part of a way in a certain interval of time of days;
- the change of a kind of the acoustic image serves the indicator of change of behaviour and, probably, age-length characteristics of a fish and is subject to

check control trawling;

- in case there is record of object in various depth horizons, control trawlings are carried out for separate identification of each type of schooling.
- in accordance with receipt acoustic data during survey the empirical analysis of echo signals, taking into account character of behaviour of object, type of distribution of target strength (TS, dB), results control trawling, experience of previous work in the certain region came true. In result of the conducted analysis of an acoustic situation parts of a way on transects of acoustic survey, schoolings appropriate to the characteristic acoustic description with certain length category, confirmed by results control trawlings on certain schooling. Were allocated, in the subsequent such part of a way and length-frequent line appropriate to a schooling were used for biomass calculation of an identified schooling on the given piece of acoustic transect.

Calculating of signals is made on echo processing system EP 500 Simrad by a echo-integration method. The values received as a result of surface back scattering strength S_a ($m^2/mile^2$) were converted in area density values of fishes one-size group i ($ton/mile^2$) using the following general formula:

where: ω_i - mean weight of i -size group of fish (g),

$$\rho_i = S_a \cdot \frac{f_i}{\sum_1^n f_i \cdot \sigma_i} \cdot \omega_i \cdot 10^{-6};$$

σ_i - mean value of acoustic back-scattering cross section of i -size group of fish (m^2).

$$\sum_1^n f_i = 1$$

f_i - share of i -size group of fishes in control trawl,

n - amount of size groups by results of trawling.

Surface density values of fishes all size groups was computed as:

$$\rho = \sum_1^n \rho_i$$

In turn the acoustic back-scattering cross section was determined through target strength (TS_i , dB) under the formula:

$$\sigma_i = 4\pi \cdot 10^{TS_i/10};$$

For recalculation li (cm) – fork length of pollock (biological characteristic) in the appropriate to it target strength of fish (the acoustic characteristic of reflective ability) fish was used the equation (Traynor, 1996):

$$TS_i = 20 \cdot \text{Log}_{10} [l_i] - 66;$$

During biomass estimation a method of selective processing of acoustic data was used. It is caused by that at the system, regular collection of acoustic data in a course echo sounding take place large variations of echo-intensity. The essence of a method is, that all echo-intensity (density), survey received in region, are distributed on “ n ” of numerical intervals ($j=1,2,3,\dots, n$ - gradation). Let, the area of region is equal “ S ”, total of elementary sampling distance unit (*ESDU*) in region is equal “ N ”, the amount of *ESDU* with echo-intensity in a numerical interval “ j ” is equal “ N_j ”. It's suggested, that the area, occupied by echo-intensities in the interval “ j ”, is equal:

$$S_j = \frac{N_j}{N} \cdot S$$

In this case dispersion and error at processing become less significant in comparison with classical ways of processing, also spatial influence of autocorrelation between acoustic measures decreases, as datas in each numerical interval “ j ” can get echo-intensities from different places of region.

The essential difficulties of detection and quantitative estimation arise during the work with semi-demersal of concentration in habit. By virtue of the various reasons they only are partially registered by echo sounders. To estimate such concentration can be possible only by a echo integration-trawl way (Yudanov, 1992). Taking into account, that vertical opening of bottom trawl was 4 m, it was made a decision to carry out echo-integration in a pelagic layer, excepting signals from bottom layer (4-0.5 m from the bottom). During result processing of area back scattering coefficient Sa ($m^2/mile^2$) in the bottom layer was ignored.

To interpolate fish surface density values, the geostatistical gridding method of "Kriging", as recommended FAO a method of fields construction of biomass distribution by results of EIT surveys was used.

Biomass of fish aggregations is calculated as:

$$W = \sum_1^n W_j = \sum_j^n \rho_j \cdot S_j;$$

where: W_j – biomass in each gradation or on each part of region,

(tons);

n – number of gradation or parts of region.

Dispersion of density values ($[\text{ton}/\text{mile}^2]^2$) in each gradation:

$$D_j^2 = \frac{\sum_{i=1}^{m_j} [\rho_j - \rho_i]^2}{m_j - 1};$$

where: p_j – mean value of density, appropriate “ j ”-th gradation,

$$\rho_j = \frac{\sum_{i=1}^{m_j} \rho_i}{m_j};$$

where: p_i – current value of density in “ j ”-th gradation, ($\text{tons}/\text{mile}^2$);

m_j – number of datas, appropriate “ j ”-th gradation.

Error of biomass estimation of fishes on all region was calculated under the formula:

$$\varepsilon_w = \pm t(m) \cdot \sqrt{\sum_{j=1}^n \frac{D_j^2 \cdot S_j^2}{m_j}};$$

$$m = \sum_{j=1}^n m_j;$$

where: $t(m)$ – value of Student t -distribution.

Fish on and near bottom were sampled with midwater trawl equipped with roller gear. Horizontal opening for the trawl averaged about 20.5 m. Vertical opening – 4 m. The trawl net had stretch mesh size to 1.0 cm in the codend. Vertical net opening and depth were monitored with a Koden wireless net sounder system attached to the headrope.

In places of the greatest concentration of fishes was carried out 18 control trawls, duration on 30 minutes each, on depths from 90 meters up to 287 meters (Fig.1). For each haul were used to provide total weights and numbers of individuals by species. Pollock were further sampled to determine sex, fork length, body weight, age and maturity.

Surface density values of fishes ($\text{tons}/\text{mile}^2$) in a layer of trawling was computed as:

$$\rho = \frac{1852 \cdot W_t}{K_y \cdot S_t};$$

where: W_i – sample weight of trawl (tons);

- S_t - fished area (mile²);
 K_y - coefficient catchability of trawl ($K_y=0.4$).

Fished area was computed as:

$$S_t = h_t \cdot v \cdot t;$$

- where: h_t - horizontal opening of trawl (m²);
 v - speed of trawling (knots);
 t - time of trawling (hour).

Software used at calculations (Excel, Surfer), and also the developed programs of thematic data processing (Biomass) provide calculation of errors of biomass estimations of fishes as on each gradation, and on the whole region. However it is necessary to mean, that the getting errors were calculated by the account only variations of integrals (density) of fish aggregations inside gradations and on region of surveying, i.e. are not complete errors, the calculation of which is impossible practically at the moment.

Acoustic data were collected using a Simrad EY 500 echo-sounding system operating at 38 kHz. Specifications of the acoustic system during the present survey were following:

- pulse duration - 3.0 ms (Long);
- band width - narrow (0.38 kHz);
- absorption loss coefficient - 10 dB/km;
- TVG function – 20 LogR;
- TS threshold = -60 dB;
- Sv threshold = -70 dB;
- sound velocity - 1490 m/s.

The echo sounder was calibrated using a 60 mm copper standard sphere with a TS of -33.6 dB using the technique described by Foote et al. (1987). The measurement of a noise level was carried out at various speeds of a movement of a vessel according to the methodical work instructions with echo sounder EY 500. Thus mean value of noise power on the antenna of echo sounder, recalculating to 1 W, at speed of a movement of 5 knots was - 139.9 db. During carry out of echo survey ESDU was choose 1.0 miles.

Echo recording of walleye pollock were found in horizon from 70 up to 100 m, independently of time of day. In too time was present also insignificant bottom component distributions of fish, which conduct was determined by time of day: during day laid on a ground and practically was not registered by an echo-sounder, at the night - was diffused in a pelagic layer and was registered to within single fish.

Besides of pollock were registered shoals of capelin and herring in horizon from 20 up to 70 m., which were are excluded from analysis at post-processing the received echograms.

Walleye pollock was the dominant species (up to 92%) captured in trawls. The size of a pollock varied from 11 up to 67 cm. Average length of a pollock was 30.6 cm. It the most significant aggregation were observed during conducting of transect №1 in coordinates 61°00N; 179°30W. The values of Sa on this part of transects was $3033 \text{ m}^2/\text{mile}^2$ (194,1 tons/mile²).

Echo-integration of the other parts of transects has shown significant increase of density of registered shoalings – Sa values occasionally exceeded values in 1000 m^2/mile^2 , at mean: $342 \text{ m}^2/\text{mile}^2$ (28,4 tons/mile²).

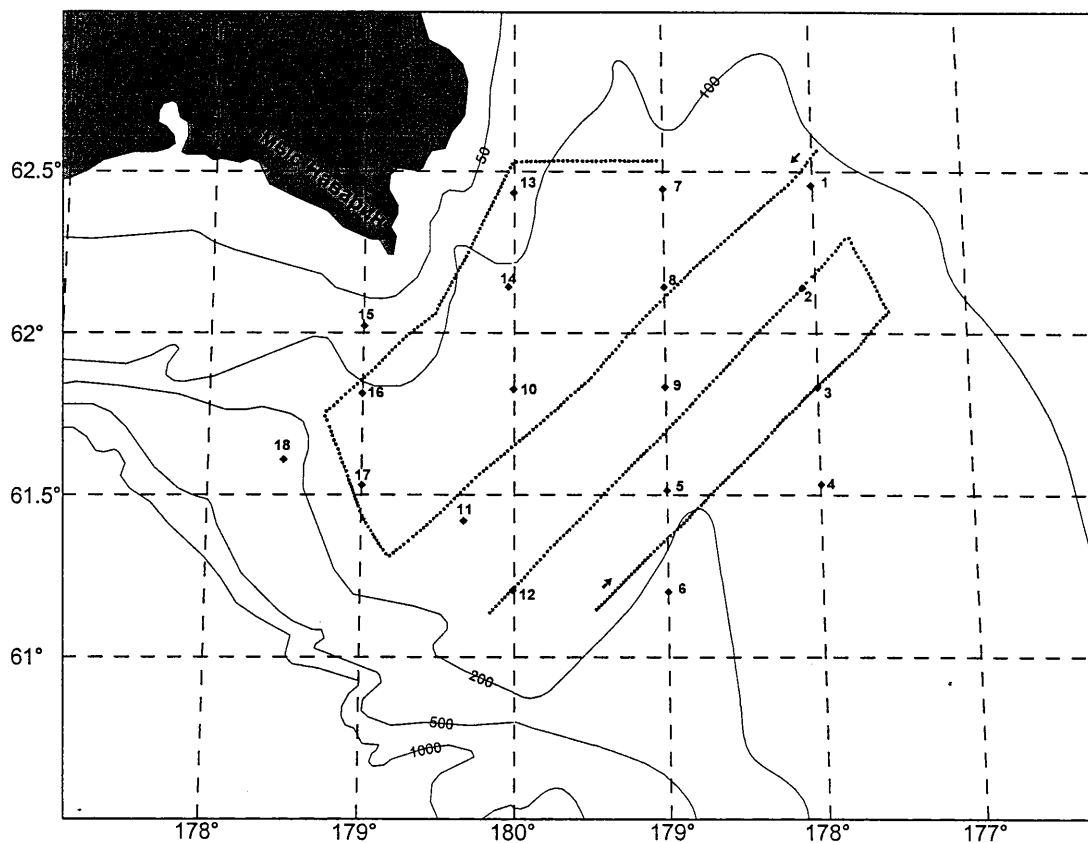


Fig. 1. Plot of hydroacoustic surveys and control trawls, carried out by a vessel "Kaye-Maru № 28 " from October 28 to November 4, 2002.

For biomass calculation the dependence of pollock weight versus length was computed from measurements of 1001 fish with length from 17.5 cm to 86 cm (Table 1), with correlation coefficient 0,97:

$$w = 6.5 \cdot 10^{-3} \cdot l^{3.04}$$

,where: w – weight of pollock (g);
 l – length of pollock in cm.

Table 1

Average and standard deviation of length and weight of Walleye pollock by results of cath data.

	Mean	St. deviation	Minimum	Maximum
Length(cm)	45,9	10,6	17,5	86,0
Weight(g)	889,9	637,1	60,0	5200,0

The dependence of weight on length, received by results of measurements of 1001 fish is introduced on Fig. 2.

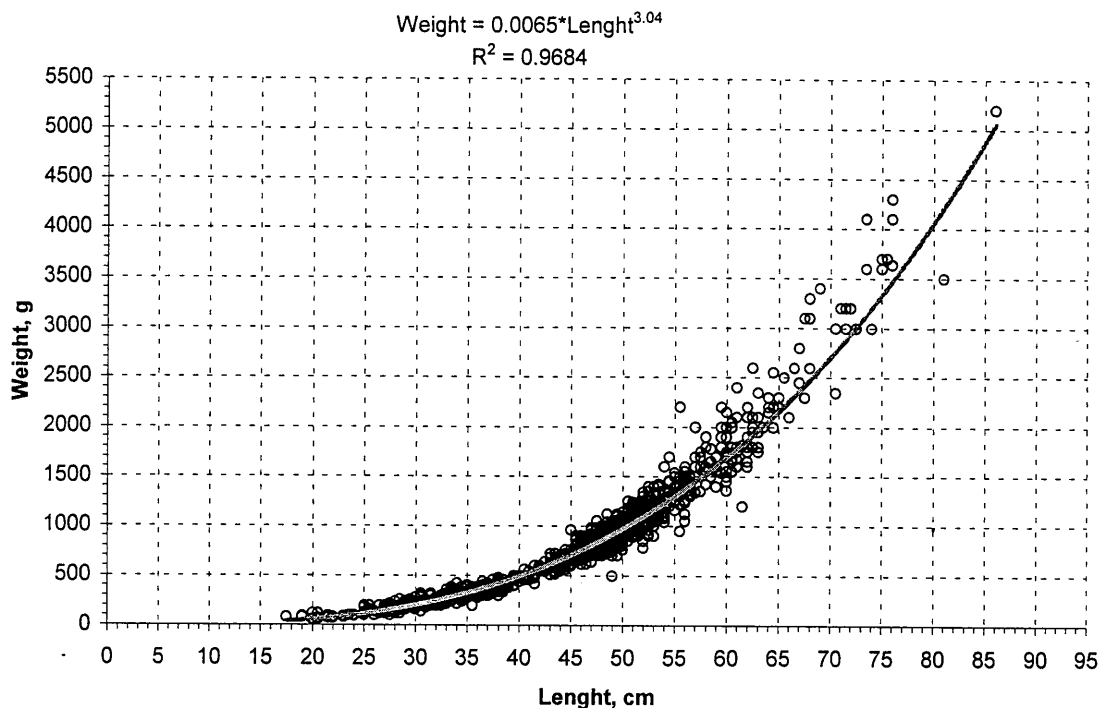


Fig. 2. Dependence of weight from length of Walleye pollock.

At plotting of area density distributions of pollock, for interpolation of area density values, display of a field of biomass distribution, its a quantitative estimation and calculation of each gradation area was used the “Surfer” software (Golden Software, USA) and “Biomass” software (VNIRO).

To study the spatial structure of pollock distribution, experimental omnidirectional standardised variograms were calculated on the respective estimated fish density. Variograms were fitted by visual inspection to exponential model. Software allows the user to monitor the goodness of fit resulting from the adoption of different choices for the parameters of the model, in order to find the best possible fit. The parameters of the exponential fit to the experimental variogram so obtained were then applied to implement Kriging interpolation method for biomass estimation and mapping purposes.

The parameters for calculating of density values in points of a regular grid were following:

- method of interpolation - Point Kriging;
- model of variogram - Exponential
- (Scale = 1126; length = 13.739; anisotropy = 1.613, 119.1)
- scale of regular grid - 1 mile X 1 mile.

Area density of Walleye pollock by results of echo integration changed in limits from **0.04 up to 198.65 tons/mile²**
(mean = 28,44 tons/mile²; st.dev = 33,34 tons/mile²).

Table 2 represent the biomass calculations results of hydroacoustic survey on the area 10084 mile² in the whole water column of fish distribution.

The distribution of pollock area density (tons/mile²) plotted on Fig. 3.

Table 2

Biomass calculations results of Walleye pollock in the whole water column.

Gradation [ton/nm2]	Area [nm2]	Density [ton/nm2]	Biomass [ton]	Confedence Interval[±ton]
0 - 9	1471	5,0	7285,7	184,5
9 - 18	1746	13,7	23881,8	208,1
18 - 27	2272	22,6	51379,0	240,3
27 - 38	2344	32,1	75319,3	293,3
38 - 45	681	41,1	28018,9	99,7
> 45	1570	72,4	113651,0	1864,8

Total Area = 10084[nm2]

Total Biomass = 299535,7 ± 1925,7[ton]

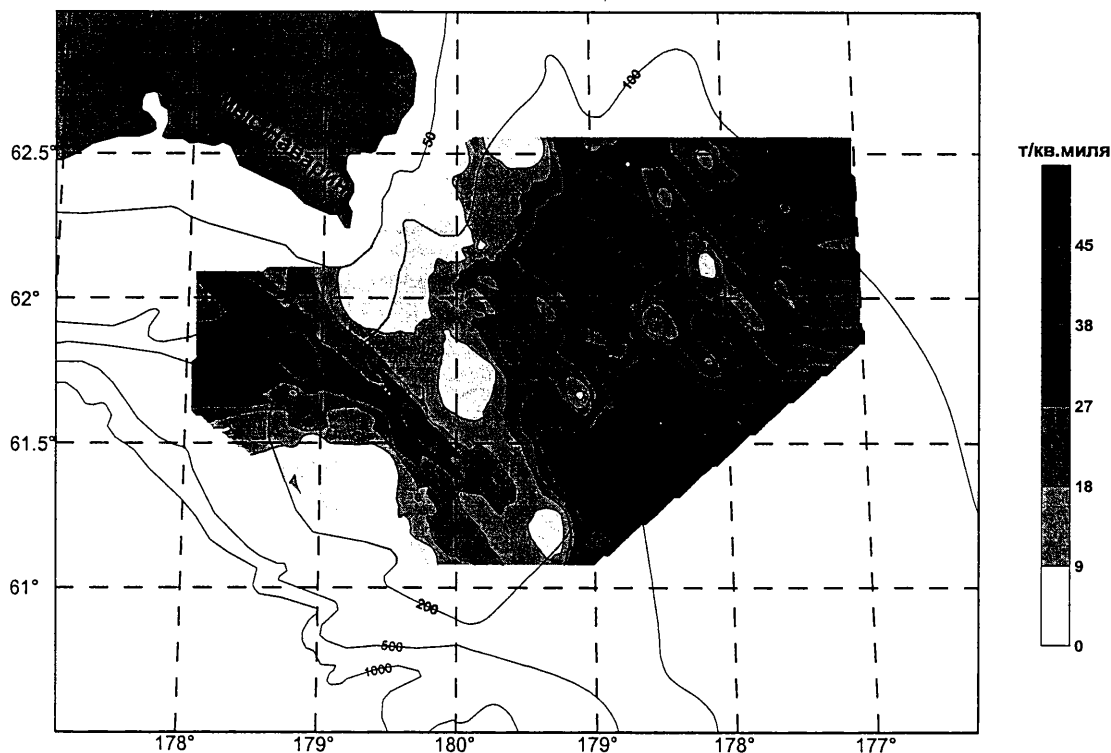


Fig. 3. The distribution of pollock area density (tons/mile²) of hydroacoustic surveys, carried out by a vessel "Kaye-Maru № 28 " from October 28 to November 4, 2002

Table 3 represent the biomass calculations results of hydroacoustic survey of fish distribution for fish with length more then 35 cm. The conforming distribution of pollock area density (tons/mile²) plotted on Fig. 4.

Table 3

Biomass calculations results of Walleye pollock in the whole water column.
(length > 35 cm.)

Gradation [ton/nm2]	Area [nm2]	Density [ton/nm2]	Biomass [ton]	Confedence Interval[±ton]
0 - 9	2429	5,3	12772,2	238,7
9 - 18	4198	12,8	53587,5	316,6
18 - 27	1515	21,8	33075,5	192,2
27 - 38	961	32,0	30732,9	192,6
38 - 45	290	41,0	11897,6	65,8
> 45	691	70,6	48774,4	1059,6

Total Area = 10084[nm2]

Total Biomass = 190840,1 ± 1165,4[ton]

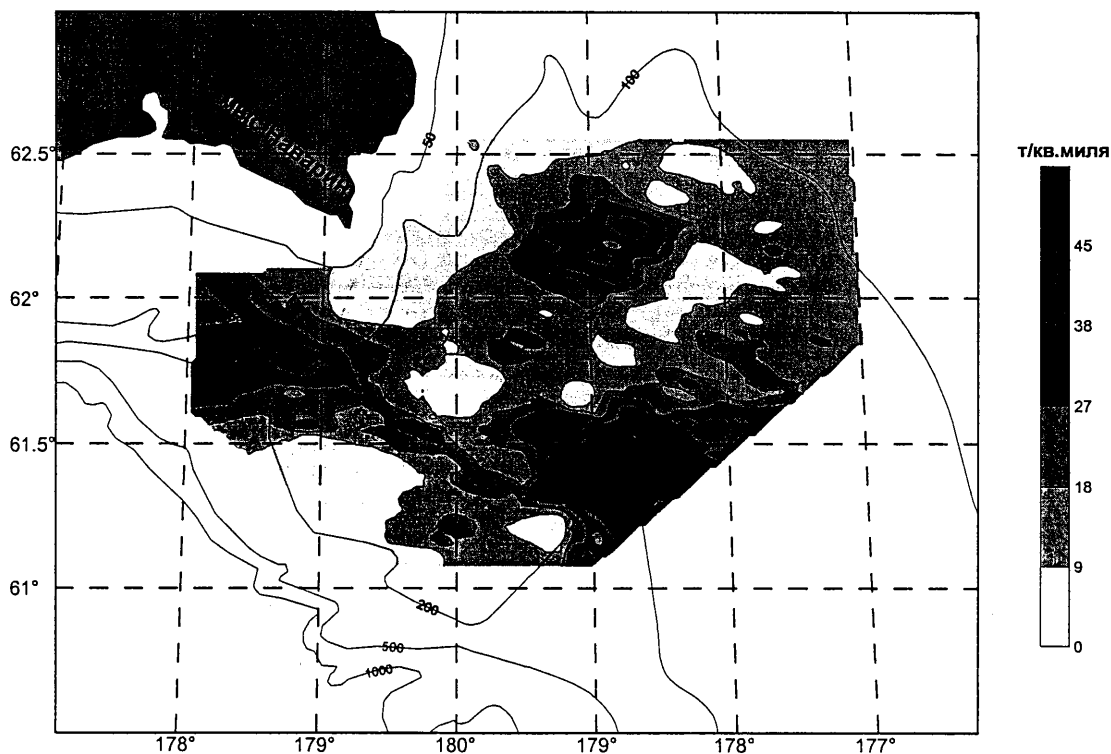


Fig. 4. The distribution of pollock area density (tons/mile²) of hydroacoustic surveys for fish length more than 35 cm, carried out by a vessel "Kaye-Maru № 28 " from October 28 to November 4, 2002.

Table 4 represent the biomass calculations results of hydroacoustic survey of fish distribution for fish with length less then 35 cm. The conforming distribution of pollock area density (tons/mile²) plotted on Fig. 5.

Table 4

Biomass calculations results of Walleye pollock in the whole water column.
(length < 35 cm)

Gradation [ton/nm2]	Area [nm2]	Density [ton/nm2]	Biomass [ton]	Confedence Interval[±ton]
0 - 9	5677	3,2	17993,3	354,8
9 - 18	2142	13,0	27930,0	237,8
18 - 27	1586	22,1	34997,8	188,7
27 - 38	441	30,3	13348,8	114,1
38 - 45	53	41,3	2187,5	29,1
> 45	185	72,3	13375,9	622,4

Total Area = 10084[nm2]

Total Biomass = 109833,2 ± 786,9[ton]

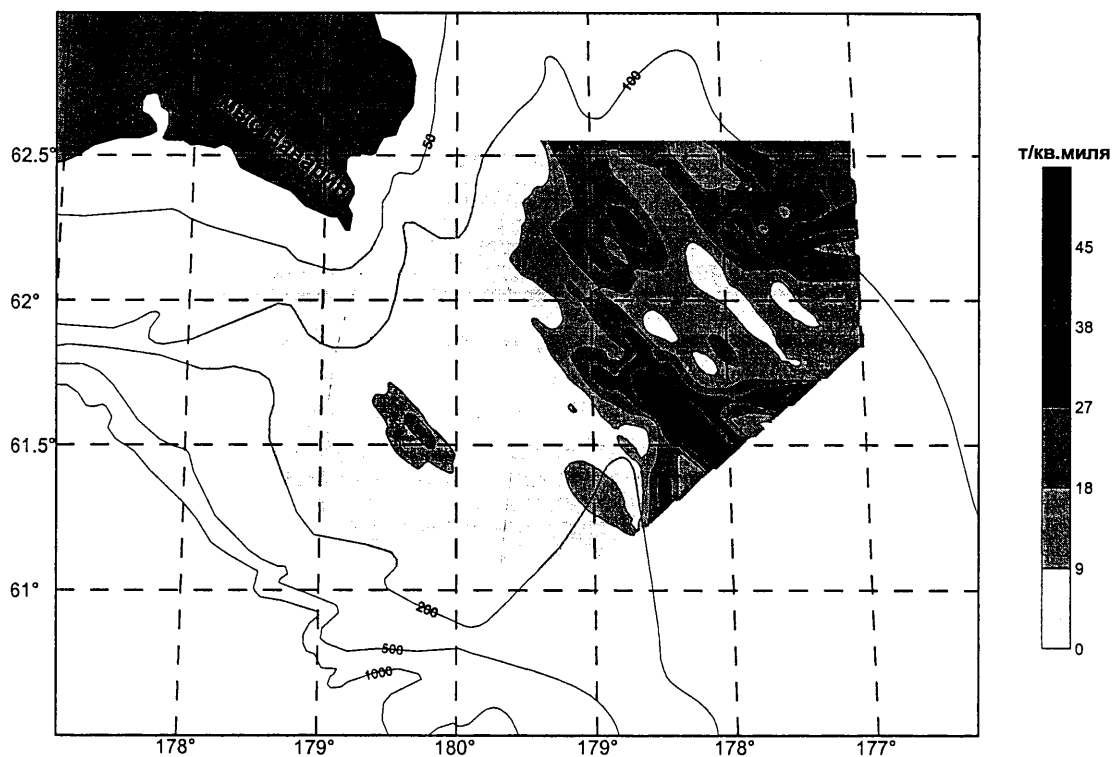


Fig. 5. The distribution of pollock area density (tons/mile²) of hydroacoustic surveys for fish length less than 35 cm, carried out by a vessel "Kaye-Maru № 28 " from October 28 to November 4, 2002

For comparison (Fig. 6; Table 5) the distribution of pollock area density (tons/mile²) of walley pollock by results of EIT surveys in October 2001 is represent.

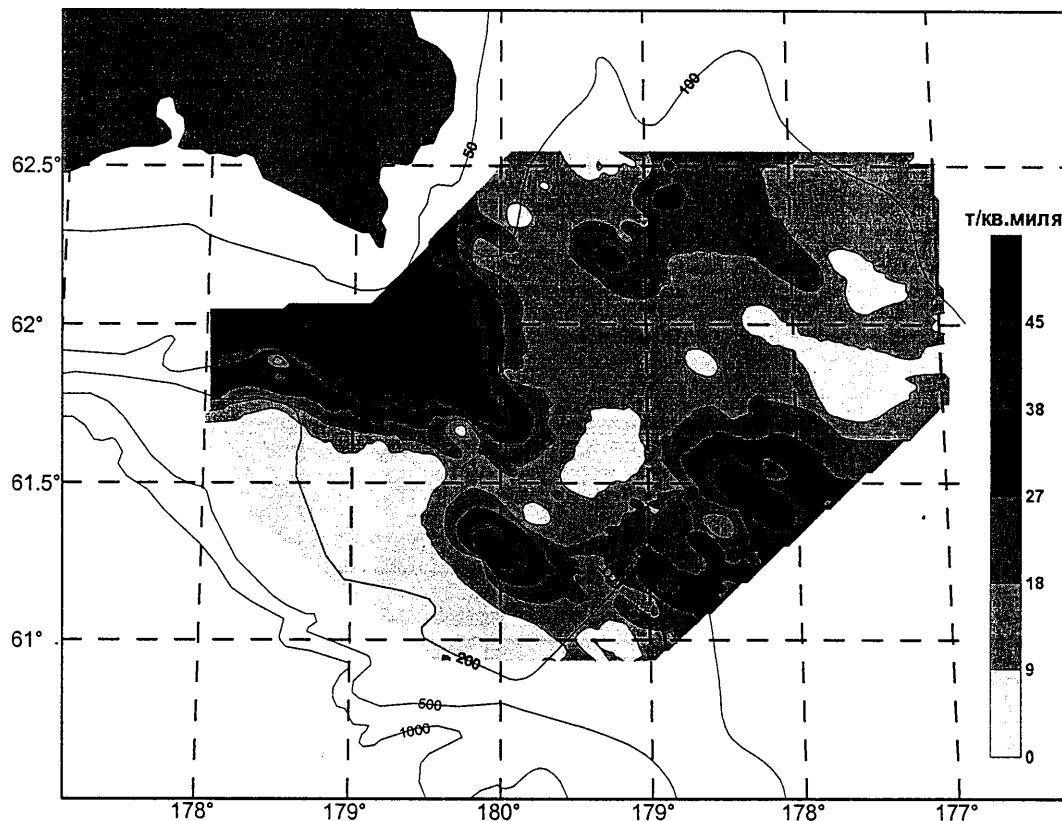


Fig. 7. The distribution of pollock area density (tons/mile²) of hydroacoustic surveys, carried out by a vessel "Kaye-Maru № 28 " from October 25 to November 5, 2001

Table 6

Biomass calculations results of Walleye pollock in October 2001.

Gradation [ton/nm ²]	Area [nm ²]	Density [ton/nm ²]	Biomass [ton]	Confedence Interval[±ton]
0 - 9	2351	4,5	10564,4	281,8
9 - 18	3995	13,2	52666,1	306,2
18 - 27	2015	21,8	43960,9	226,6
27 - 38	903	31,2	28170,8	182,4
38 - 45	277	41,3	11443,1	67,2
> 45	1025	73,4	75222,8	1466,5

Total Area = 10566[nm²]

Total Biomass = 222028,1 ± 1553,3[ton]

It is not difficult to notice, that there was a redistribution of shoals of walley

pollock: the part of “coastal pollock” was reduced. Biomass of walleye pollock in October 2001 was 222 028.1 tons on the area 10 566 mile² (recalculation on area in 10 084 mile² is 211 899.6 tons). Increase of biomass has made 41.35%.

Total biomass of Walleye Pollock on data of EIT survey in region was:

299 535.7 tons on the area 10 084 mile².

The calculations carried out on the data of bottom trawl survey have shown, that on area of a Navarin polygon, which square compounded 10084 mile² biomass hardly less than **1 725 500 tons** (Fig 7; Table 6).

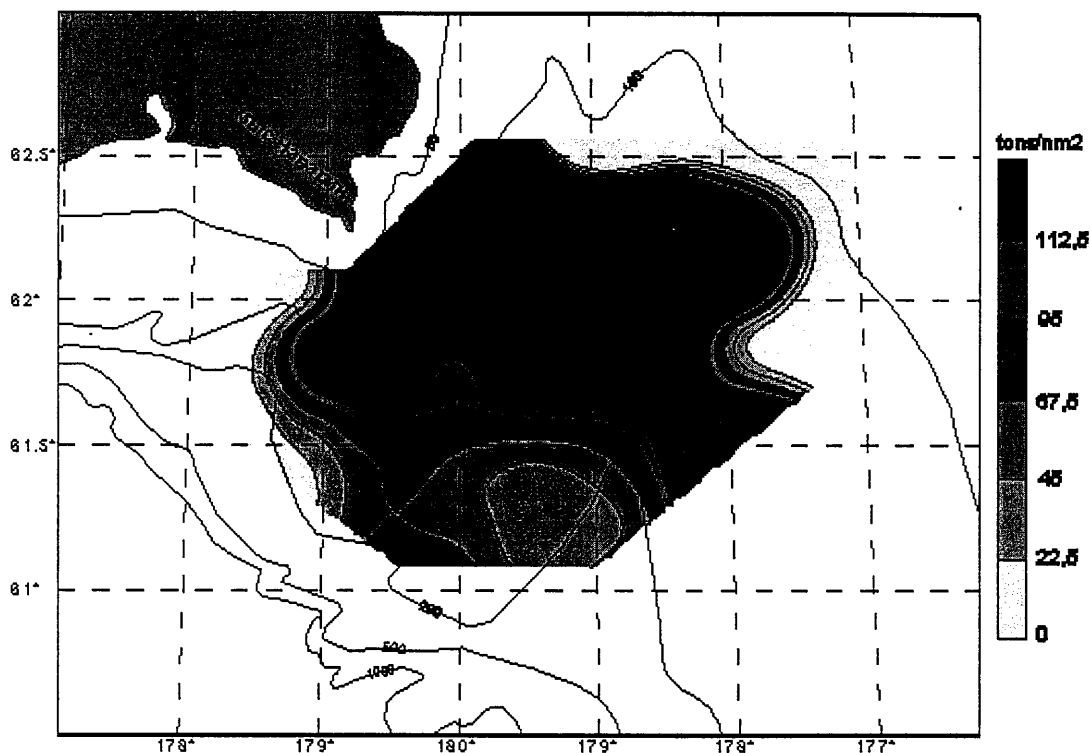


Fig. 7. The distribution of pollock area density (tons/mile²) of bottom trawl survey, carried out by a vessel "Kaye-Marú № 28 " from October 28 to November 4, 2002

Table 6
 Biomass calculations results of Walleye Pollock
 by results of bottom trawl survey

Gradation [ton/nm ²]	Area [nm ²]	Density [ton/nm ²]	Biomass [ton]	Confedence Interval[±ton]
0-22,5	1869	2,5	4672,5	452,8
22,5-45	907	34,5	31291,5	365,3
45-67,5	1041	57	59337	421,0
67,5-95	990	78,5	77715	492,0
95-112,5	432	103,5	44712	202,8
>112,5	4845	311,2	1507764	21803,8

Total Area = 10084[nm²]

Total Biomass = 1725492+21822[tons]

REFERENCES

- Foote, K.G., H. P.Knudsen, R. J. Korneliussen. P. E. Nordbo, and K. Roang. 1991. Postprocessing system for echo sounder data. J. Acoust. Soc. Am. 90:37-47.
- Traynor, J. J. 1996. Target strength measurements of walleye pollock (*Theragra chalcogramma*) and pacific whiting (*Merluccius productus*). ICES Journal of Marine Science, 53: 253-258.
- Traynor, J. J. and M.O. Nelson. 1985. Methods of the U.S. hydroacoustic (echo integrator-midwater trawl) survey. Int. North Pac. Fish. Comm., Bull. 44; 33-40.
- William A. Karp and Gary E. Walters, Survey Assessment of Semi-pelagic Gadoids: the example of Walleye pollock, *Theragra chalcogramma*, in the Eastern Bering Sea, Marine Fisheries Review
- K.I. Yudanov, Hydroacoustic investigation a fish, S.Peterburg, "Shipbuilding", 1992., pp.185.

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**DISTRIBUTION AND ABUNDANCE OF POLLOCK JUVENILES IN
THE WESTERN BERING SEA IN SEPTEMBER-OCTOBER 2002**

(document submitted for VIII Bering Sea Pollock Conference, Portland, 2003)

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