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International Council for the Exploration of the Sea

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Demersal Fish Committee

Report of the Workshop on Age Determination of Redfish

Murmansk, 26-30 August 1991

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Report of the Workshop on Age determination of Redfish

1. INTRODUCTION

1.1. Terms of Reference

The Workshop on Age determination of Redfish met in Murmansk (USSR) in Polar Research Institute (PINRO) 26-30 August 1991. The terms of reference were set by the Council's resolution, passed at 78-th ICES Statutory Meeting (C. Res. 1990/2:14) to:

a) compare and contrast, in consecutive annual data sets, presumptive age determinations of S. mentella and S.marinus from length-frequency distributions with those from otolith zone readings;

b) discuss the benefits of using different hard parts or scales for ageing these species.

1.2. Participants

B.K. Berntsen	Norway
K.V. Drevetnyak	USSR
G. Haunschild	Germany
K. Nedreaas	Norway
I.A. Oganin	USSR
A.I. Pavlov (Chairman)	USSR
F. Saborido Rey	Spain
M.V. Vaganova	USSR
E.A. Varlamova	USSR
V.V. Volkova	USSR

1.3 Previous experience

Although scientists from many countries have focussed on age determination of Sebastes for decades (e.g., ICES 1983, 1984), there are still different methods in use. Differences in the age-reading results between the countries fishing for redfish create severe inconsistencies in the catch-at-age matrix used in assessment.

Scientists from Canada and the USA have recently agreed upon counting the numbers of rings or annuli on a lateral cross section of a broken and burnt otolith instead of on the exterior of the whole otolith (e.g., Beamish 1979, Chilton and Beamish 1982,

Boehlert and Yoklavich 1984, Wilson and Boehlert 1990).

European scientists, on the other hand, have until recently only used scales for age determination of Sebastes. The scales have after rinsing generally been read in two ways, either under polarized light (Surkova 1961, Chekhova 1971, Haunschild 1978), a technique which Kosswig (1971, 1973, 1980) perfected by impregnating the scales with silver nitrate, or they have been read in ordinary transmitted light (Pavlov MS 1991).

Among the European countries fishing for Sebastes, Iceland, Denmark, the Faroes and the German laboratory in Bremerhaven/ Hamburg are today using the scale method described by Kosswig. Eastern European countries, including USSR, Bulgaria, and the German laboratory in Rostok read the scales in ordinary light by means of a projector for microfilms (Figure 2). After for some time reading both scales and otoliths for comparison, Norway and Spain are today routinely reading broken and burnt otoliths.

Nedreaas (1990) presents the results of comparative age readings conducted in America and in different European countries, using both scales and otoliths from same specimens of Sebastes marinus and Sebastes mentella. Significant and unacceptable differences were found.

There have been two previous ICES Workshops on ageing of redfish (ICES 1983, 1984), and the recommendations from these Workshops can be summarized as follows:

a) exchanges of material between European and North American researches and publishing of the results;
b) tagging studies of inshore or pelagic stocks;
c) further studies of radionucleotides;
d) whether age / lenght keys vary from year to year in a density dependant manner.

The North-Western Working Group (ICES 1990a) and the Study Group on oceanic-type Sebastes mentella (ICES 1990b) have later recommended that the scale method should be verified by comparing scales and otoliths from fish species where both structures are considered to yield reliable results, e.g., for cod and haddock.

To improve the reliability of the assessment, it is necessary to harmonize the age readings. Recommendations about this have therefore recently been put forward from both the Arctic Fisheries Working Group (ICES 1990c), the North-Western Working Group (ICES 1990a) and the oceanic-type S.mentella Study Group (ICES 1990b). It may take some time to agree upon only one method to use. However, in this process it is urgent for all the involved countries to participate.

Important work has already been published. Bennet et al. (1982) conducted radiochemical assay (Pb-210/Ra-226) of entire otoliths, concluding that the Pacific species Sebastes diploproa lived to ages only possible to read from otoliths when these were broken and burnt. Campana et al. (1990) increased the precision of this geochronological technique by restricting the analysis to the

extracted otolith core. Measurement of the radioactive disequilibrium between Ra-226 and Pb-210 confirmed their interpretation of annuli in a broken and burnt otolith from Sebastes mentella to at least an age of 65 years. The use of the ratio of Pb-210 to Ra-226 to date geological samples is well established, and is firmly based on physical laws of radioactive decay.

Another important work is the mark-recapture study by Leaman and Nagtegaal (1987) where they used oxytetracycline (OTC) injections to validate the annual pattern of banding in broken and burnt otoliths of Sebastes flavidus. Nedreaas (1990) also recommends to use broken and burnt otoliths. This he concludes after comparing scales and otoliths with independant growth data obtained by following a strong year class of Sebastes mentella, and also studying the relative growth of the structures used for age determination (otoliths and scales) and the fish itself.

Age reading experts from Cuba, Bulgaria, Germany (Rostock) and the USSR conducted an international ageing Workshop on redfish in Rostock in 1989 and further exchange of material was arranged in 1990 (Haunschild et al. MS 1991). They explained the reasons for the differences in age reading (both otoliths and scales) to be the interpretation of the nucleus, the first annual ring and the narrow rings at the edge. They further hoped that the radiochemical method decribed by Campana (1990) could give clearness in this problem.

The correctness of the age reading by the scale methods used within ICES has so far not been verified and no direct method to test it has been found. The otoliths when broken and burnt, however, have in several validating and growth studies shown to give the most correct age of redfish. Otolith interpretation is not without its problems, however, and requires considerable care, skill and experience.

2. MATERIALS AND METHODS

The materials used for demonstrating the different international age determination methods and discussing the interpretational differences were provided by Norway, USSR, and Spain. It consisted of otoliths and scales from S.mentella, S.marinus and S.viviparus from Barents Sea, Norwegian Sea and Flemish Cap (Table 1).

A total of 11 samples and 58 specimens were determined by different age determination methods. The largest pair of otoliths, the sagittae, were used. Common names for different parts of the otolith and the preferred counting area are shown in Figure 1. The scales were taken from each fish below the lateral line, above and behind the posterior part of the pectoral fin. Both structures were stored dry together in the same paper envelope (in Germany (Rostock) they were stored deep frozen).

To compare the different determination methods the scales were first

read unstained, after washing in a 1-2% ammonium solution, between two microscope slides with the help of 5-PO-1 microphot projector (Figure 2) in ordinary light, and thereafter also unstained by binocular but in polarized light. The second way was to wash the scales in a 5% KOH solution and to stain them in a 1.0% silver nitrate ($AgNO_3$) solution before reading in polarized light by means of a binocular (Kosswig, 1971, 1973, 1980).

The otoliths were sawed or broken in half through the nucleus. At one method the surface of the broken otolith was carefully burnt in an alcohol flame. The burnt, and with groundnut oil coated surfaces, the otoliths were read in reflected light (Nedreaas, 1990). At the other method the broken otoliths were burnt for 1 hour at 200°C in an oven and then read in transmitted light (Saborido Rey, 1991).

3. RESULTS

Results from the different demonstrations described in chapter 2 are summarized in Tables 2-9. All preparations were read "blind" by each country without knowing the fish length.

The results in Tables 2-5 are from the same specimens and so are also the results in Table 7 and 8. For both data sets it is clear that the scale readings, using the different kinds of treatment, differed more than the otolith readings when comparing the different readers. The differences seem to increase for fish of greater lengths. Differences between the mean ages read by each reader/country, for fish between 14-30 cm, were for the scale determinations between 2.8 and 5 years while for the otolith readings it was around 1 year (Tables 2-5). For these small fishes the age determinations of scales were above those of otoliths.

For larger redfish between 35 and 41 cm these differences increased to 6.1 years for scales and 4.23 years for otoliths (Tables 7, 8). The ages of these larger fish were higher using otoliths than scales. Table 6 shows a good conformity in the otolith readings of S. marinus from Flemish Cap with average difference between readers of less than 1 year.

In Table 9 results from additional readings of otoliths of S. marinus and S. viviparus are shown. Both species seem to possess well readable otoliths both for small and larger fish. The differences between the readers were for marinus and viviparus on average 2.6 and 2.3 years, respectively.

The results from all readings showed a better corformity between readers for otoliths than for scales, although not all of the participants had previous experience in using otoliths.

4. DISCUSSION AND ADVICE TO SCALES AND OTOLITHS READERS

The main task of the Workshop was to compare and contrast age determination methods for redfish, and to discuss and evaluate the use of otoliths vs. scales. The different age reading methods used today have during this Workshop been demonstrated. Most of the participants had little previous experience with at least one of the demonstrated methods, and this may have influenced the results, although an introduction to the different methods was given before each reading experiment. The results presented in the tables should therefore be looked upon as the results from a demonstration of methods and not as a complete age determination study of the different stocks.

Due to problems in travel fundings and/or the political happenings in the USSR a few days before this Workshop, the number of participants was less than expected. However, this gave time for many important discussions with scientists from the USSR, who had not participated in the previous two ICES Workshops. The most important outcome from this Workshop was perhaps the opportunity to inform each participating age reader about the latest results in this field and to demonstrate different methods.

The Atlantic Sebastes scales may show strong patterns, and the scale readings during this Workshop indicated that Sebastes scales from West-Atlantic were easier to read than scales from e.g. the Barents Sea. Readings of the scales from fish up to approx. 12 years may give the same age as that read from the otolith, although not-systematically differences occur (Nedreaas 1990). Regarding this matter, the Workshop refers to Nedreaas (1990), Haunschild et al. (MS 1991) and Pavlov (MS 1991) who have analysed a greater material and presented a more detailed discussion and explanation.

All the participants in this Workshop agreed upon that the interpretation of scales was more incidental and difficult to rely on than the reading of otoliths. Obviously the interpretation of otoliths has improved a lot due to the burning and subsequent coating of the cut otolith surface with oil. Although correct interpretation of the otolith needs some training and experience, the opinion of the Workshop is that it was easier for everybody to understand how the otoliths should be interpreted, and that future agreement in the reading would be easier to achieve reading otoliths than scales.

And most important, that the reader feels that the structure he is reading is a validated and biologically correct structure to use. Nevertheless, occasional disagreement about whether a zone should be regarded as an annual growth zone or a false zone will always happen, but this should in the long term not create any severe errors.

By conducting different methods of age reading at this Workshop, the objective was not to validate the methods. It is, however, strongly recommended (e.g., Beamish and McFarlane 1987) that even for a validated method comparisons among structures should be a rountine procedure for any laboratory providing age determination estimates for

management.Exchange of material between countries, or preferably regular Workshops should be recommended and that would improve the consistency of the international age determinations.

Two ways of reading the broken (or sawed) and burnt (alcohol flame or oven) otoliths were demonstrated, either in reflected light (e.g., Canada, USA, Norway) or in transmitted light (e.g. Spain). The opinion of the Workshop is that each age reader must decide upon in what light to read the otoliths since no differences between these methods were observed.

The USSR age readers routinely use a modified projector for microfilms when reading scales in ordinary light (Figure 2). The members of the Workshop felt it very pleasant to use the USSR projector instead of staring into the binocular. It should be possible to construct a similar device for reading broken otoliths. The Workshop was informed about that computers and video monitors today are used and probably will be further developed for age determination.

The occurence of strong year classes in length frequency distributions can be used for validating the age reading. This method was used by Nedreaas (1990) when he followed the strong 1982-yearclass of S.mentella. Using this kind of method it is important to cover the entire area of the species distribution in order to be sure that migrations would not have any influences. For future research the Workshop will mention probably strong new year classes of redfish at Flemish Cap (Saborido Rey, 1991) and of S.mentella in the Barents Sea (Nedreaas, pers. comm.).

A consequence of reading otoliths instead of scales results in lower mortality and higher maximum ages for the redfish. Observations of e.g. old fish that are shorter than fish of intermediate ages, and that the age of fish of equal length may vary by up to 50 years, were discussed by the Workshop. Such biological observations are today further investigated (e.g., by Canadian scientists) and will probably be published in near future.

Scales read in polarized light has been the common method to age roundnose grenadier, Coryphaenoides rupestris (e.g. Kosswig 1974, Savvatimskii 1973), but recent work has questioned the use of scales for this species, too. Although Bergstad (1990) did not validate the otolith method for C. rupestris, he presents some biological results that support the use of otoliths instead of scales.

5. RECOMMENDATIONS

The following recommendations are the points of view of the age readers participating in the Workshop. The Workshop regrets that many countries involved in the redfish fisheries and with expertice in redfish ageing were not represented at this meeting.

1. Because of independent evidence for the correctness of using otoliths, and lack of such evidence for using other structures like scales, the Workshop recommends that broken and burnt otoliths should be the preferred structure for age determination of North Atlantic Sebastes species. In order to use scales in the future, these should be validated by independent and internationally approved methods. However, the age reading during this Workshop showed that otoliths and scales yield approximately the same age for the youngest fish (younger than approx. 12 years).

   The Workshop realizes that many countries already have a long time series of scale based age determinations. It will be up to each country to decide whether it is necessary or possible to convert old scale data so that they correspond to otolith ages. A clear and systematic relation between otolith ages and scale ages is, however, difficult to find, and it will at least need further investigation. The recommendation of using otoliths for age determination will therefore only take effect for the future.

   The Workshop strongly recommends, especially during the process of harmonizing the age readings, that comparisons between scales and otoliths be a routine procedure for any laboratory before making an eventual final decision for using one structure only in their routines.

2. It is often very exhausting and strenuous to determine the age by staring through a binocular. The Workshop therefore strongly recommends that a device (mechanic or monitor) for reading broken otoliths on a screen should be developed. If such a device already is being used for mass age readings, all involved laboratories should be informed.

3. To obtain consistency in the international age readings it is important to compare the readings regularly, also readings from different structures. The opinion of the Workshop is that this best can be achieved by having regulary ICES workshops on redfish age determination. Ref. committee of age reading experts (CARE) on the Pacific coast of USA and Canada.

4. The Workshop wants to call on all Sebastes researchers to look for the possibility to follow strong year classes and to collect otoliths and scales from these specimens. This will be useful for calibration and comparison of methods and readers. Researchers should also look for the possibility of mark-recapture studies of Sebastes species in the North Atlantic. This will give a lot of useful information besides validating the age reading.

5. Information about new papers for age determination of Sebastes spp. should be exchanged immediately between specialists from different countries.

6. REFERENCES

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Table 1. Informations about the treated material. 1) S.mentella, 2) S.marinus, 3) S.viviparus.

Sample no.	Fish no.	Treatment	No. of specimens		Area	Time of collecting	Used structures	Origin
1	1 - 10	unstained in ordinary light (microphot)	10	1)	Barents Sea	February 1991	scales	Norway
2	1 - 10	unstained, in polarized light						
3	1 - 10	stained, in polarized light						
4	1 - 10	sawed and burnt in alcohol flame					otoliths	
5	11 - 20	unstained in ordinary light (microphot)	10	1)	Flemish Cap	July 1991	scales	USSR
6	11 - 20	unstained in polarized light						
7	11 - 20	stained in polarized light						
8	21 - 40	broken and burnt in an oven	20	2)	Flemish Cap	Summer 1990 and 1991	otoliths	Spain
9	41 - 48	stained in polarized light	8	1)	Norwegian Sea	October 1990	scales	Norway
10	41 - 48	broken and burnt in alcohol flame					otoliths	
11	49 - 53	broken and burnt	5	2)	Barents Sea	November 1990	otoliths	Norway
	54 - 58	in alcohol flame	5	3)	Norwegian Sea	May 1991	otoliths	

Table 2. Results from the age determination of S. mentella reading scales in ordinary light.

Sample No.	Fish No.	Length cm	Norway 1	Norway 2	Germany	Spain	USSR
1	1	27	-	10	8	10-11	8-9
	2	27	-	11	9	10-11	8
	3	26	13	11	9-10	12	8
	4	29	12	10	12-13	15-16	9
	5	25	9	10	8	11	6
	6	27	11	-	10	-	7
	7	29	7	9-10	12	11-12	7
	8	27	7	9	8	12	7
	9	28	10	9	12	14	7
	10	29	9	10	11-12	12	7
5	11	14	3	4	3-4	3-4	4
	12	14	2	6	3-4	6	4
	13	21	3	5	4	6-7	6
	14	20	4	5	5	5	5
	15	21	4	9	7	9-10	7
	16	21	3	8-9	6	10-11	6
	17	26	4	8	7-8	9-10	8
	18	26	4	7	7-8	9	8
	19	27	4-5	13	10	11	9
	20	30	6	11	10	9	10

Table 3. Results from the age determination of S. mentella reading scales in polarized light (without $AgNO_3$).

Sample No.	Fish No.	Length cm	Norway 1	Norway 2	Germany	Spain	USSR
2	3	26	9	13	8	10	7
	4	29	-	15	9	11	-
	5	25	10	12	8	8	7
	6	27	-	13	8	10	7
	7	29	11	12	9	12	7-8
	8	27	-	10	8	10	7
	9	28	10	10	8	9	8
	10	29	10	12	8-9	12	6-7
6	11	14	4	4	4	4	3+
	12	14	6	5	4	4	4
	13	21	7	7	4	4	6
	14	20	5	6	5	5	5
	15	21	6	9	6	5	7
	16	21	6	8	7	7	8
	17	26	10	10	8	7	7
	18	26	10	11	8	8	7
	19	27	-	11	8	8	8
	20	30	6	15-16	9	7	10

Table 4. Results from the age determination of S. mentella reading scales impregnated with $AgNO_3$ and in polarized light.

Sample No.	Fish No.	Length cm	Norway 1	Norway 2	Germany	Spain	USSR
3	1	27	11	13	9	10	12
	2	27	12	13	9	12	11
	3	26	12	13	9	11	9
	4	29	16	15	10	14	-
	5	25	15	11	8	10	8
7	13	21	8	5	5	4-5	7
	18	26	10	9	6	9	11
	16	21	9	6	5	6?	6
	15	21	11	7	8	4	7
	17	26	14	9	9	7	9

Table 5. Results from the age determination of S. mentella using otoliths and reflected light.

Sample No.	Fish No.	Length cm	Norway 1	Norway 2	Germany	Spain	USSR 1	USSR 2
4	1	27	9	9	5-6	8	9-10	9
	2	27	9	10	9	7-8	8	8
	3	26	9	9	8	8	8	8
	4	29	10	4	10	10	-	10
	5	25	6	8-9	7-8	7-8	9	7
	6	27	8	9	8	7	9-10	8
	7	29	6	9	8-9	8	8-9	8
	8	27	9	9	7	8	9	8
	9	28	8	8-9	7	8	9-10	8
	10	29	9	9-10	9	10	7	9

Table 6. Results from the age determination of S. marinus by broken and burnt (oven) otoliths in transmitted light.

Sample No.	Fish No.	Length cm	Norway 1	Norway 2	Germany	Spain	USSR
8	21	21	6	5	5	6	6-7
	22	21	6	6	5	6	6
	23	20	6	6	6-8	6	6
	24	19	4	5-6	5	5	5
	25	18	6-5	5	4	5	4-5
	26	16	4	-	5-6	4	-
	27	15	6	4	4	4	4
	28	15	5	3-4	4	4	4
	29	12	4	3	3	3	3
	30	12	5	6	4	3	3
	31	9	2	2	2	2	2
	32	8	2	2	2	2	2
	33	20	5	5	5	6	6
	34	8	2	2	3	2	2
	35	31	6-7	6	5-6	10	9
	36	28	6	6	6	9	9
	37	27	4	-	4	8	6
	38	25	6	6	5-6	8	7
	39	24	5	5-6	5	7	-
	40	24	8	7	6	7	8

Table 7. Results from the age determination of S. mentella using scales impregnated with $AgNO_3$ and read in polarized light.

Sample No.	Fish No.	Length cm	Norway 1	Norway 2	Germany	Spain	USSR
9	41	41	10	18-19	14-15	9	9
	42	36	10	19	14	14	10
	43	35	9	14	12	8	10
	44	36	7	-	10-11	9	9-10
	45	36	14	16	15	11	14
	46	36	15	14	13	9	14
	47	36	10	14	12	9	9
	48	41	15	18-19	18	12-13	12

Table 8. Results from the age determination of S. mentella by broken and burnt otoliths in reflected light.

Sample No.	Fish No.	Length cm	Norway 1	Norway 2	Germany	Spain	USSR
10	41	41	19	19	16	15	19
	42	36	20	19	14	17	19
	43	35	15	13	13	14	-
	44	36	-	13	15	12-13	13
	45	36	20	20	18	18-19	15
	46	36	24	25	17	18	25
	47	36	21	18	14	17	17
	48	41	22	21	20	20	20-21

Table 9. Results from the age determination of S. marinus and S. viviparus by broken and burnt otoliths in reflected light.

Sample No.	Fish No.	Length cm	Norway 1	Norway 2	Germany	Spain	USSR
S.marinus							
11	49	46	14	14	14	17	15
	50	46	17	16	17	17-18	18
	51	36	14	13	17-18	14	16
	52	48	17	16-17	17	20	19
	53	43	14	13	15	17	15
S.viviparus							
11	54	19	11	13	12	11	14
	55	19	11-12	10	11	10	15
	56	22	13-14	13	11	10-11	14
	57	23	19	19	19-20	18-19	17
	58	20	16-17	14	16	17	16

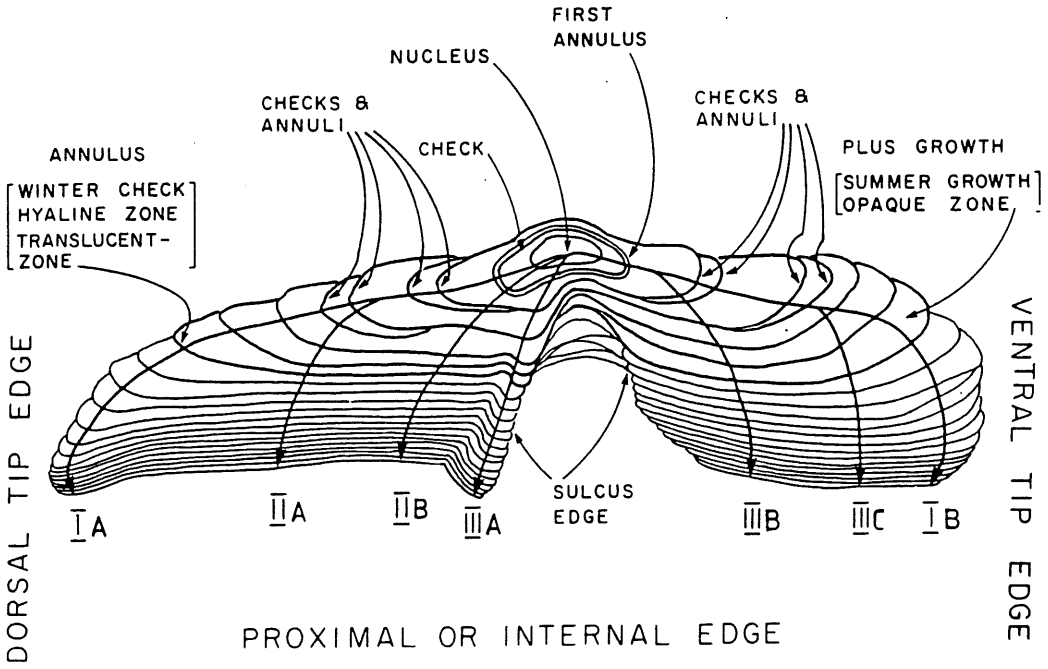

Figure 1. Drawing of an otolith cross-section from a 20-year-old fish showing areas used for counting and pertinent ageing characteristics. Arrows pointing to I indicate the fast-growing area; those pointing to II and III are slower growing areas. IIA-B is the preferred counting area for most rockfish and redfish. However, the clearest pattern may not always be on the preferred area and therefore other areas should also be examined. More than one area should be counted at all times. (Source: Chilton and Beamish, 1982).

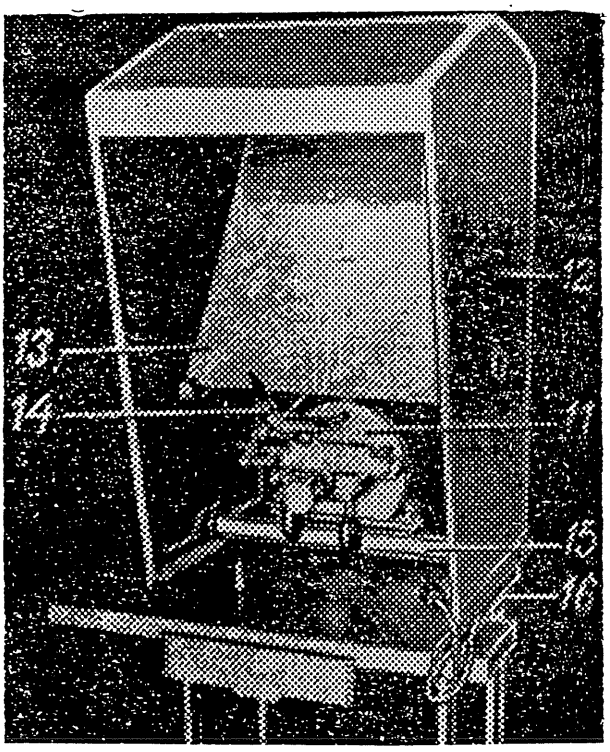

Figure 2. An illustration of the USSR microphot projector which is used for reading scales in ordinary light. For similar equipment see also Chilton and Beamish (1982).