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Report from the Norwegian-Russian workshop on acoustic echogram scrutiny

30 November – 01 December 2016 in Bergen, Norway

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Report from the Norwegian-Russian workshop on acoustic echogram scrutiny

The acoustic workshop held in 30 November – 01 December 2016 in Bergen, Norway

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Introduction

Aim of the workshop: to standardise the scrutiny of echograms during the Barents Sea ecosystem survey (BESS).

The workshop on acoustic echogram scrutiny contained both a part with practical work where the survey leaders/acousticians formed small groups of 2 or 3 persons and worked together to scrutinize selected echograms from the BESS, after which results were compared. In addition, there were plenary discussions about best practice and challenges with the scrutiny during BESS.

Background

The BESS is a compilation of what was previously several surveys with different purposes. Some of these surveys were conducted jointly between IMR, Norway and PINRO, Russia, and the BESS has since it started in 2003/04 been a joint IMR/PINRO survey. The multiple purposes of the survey make adequate data collection and processing more challenging than for standard

single species monitoring surveys. This is also the case for the *scrutiny* of the acoustic data, which is used as the term for discrimination of different targets on the echogram and allocation of acoustic backscatter to these different targets. This is a key process when acoustic data are used for biomass estimation, and it is therefore important to compare procedures for scrutiny and if possible, standardise procedures used by IMR and PINRO. That was the motivation for holding the present joint IMR/PINRO workshop.

Acoustic data collection during BESS

Acoustic data are collected continuously during the BESS. The BESS provides acoustic abundance estimates of capelin which are used in the capelin stock assessment by ICES (Gjøsæter et al. 2002, ICES 2013), and also abundance estimates of herring, polar cod and blue whiting, in addition to cod and haddock.

Splitbeam echosounders in the EK series from Simrad are applied, and they are routinely calibrated before the start of each survey. The number of frequencies applied varies with vessel. However, the 38 kHz is used on board all vessels and for all acoustic BESS abundance estimates. The values of Nautical Area Scattering Coefficient (NASC or s_A) are integrated and stored over 1 nautical mile distances. The survey approximately followed a transect grid, with variable distance between transect lines. The acoustics is supported by biological samples from trawl hauls and there are basically three types of trawl hauls in use to provide fish samples: bottom trawl hauls (Campelen 1800 for groundfish trawling), 0-group trawl hauls (Harstad trawl used for towing 10 minutes in surface-20 m and 40 m depth), and trawling according to registrations (trawling on strong echo recordings/when recordings change their characteristics and/or there is need for biological data). The data from the trawl hauls are used both as validation for scrutinising acoustic recordings, and to obtain information on essential fish parameters (individual length, weight, maturity stage, stomach content, and age) (Aglen and Gavrilov 2011).

The scrutiny of acoustic data takes place on board the vessel during the survey. Special software for processing of echosounder data is used, and the typical first steps are to omit noise, like near-field reverberation and bubble noise close to the surface and bottom echo close to bottom. Next, echo is allocated to the target species and other species or groups, using the information available from the displayed echogram, echo integrator values at different frequencies and catch composition from trawl hauls. At IMR the Large Scale Survey System (LSSS) has been used for processing in recent years while PINRO has used FAMAS, but also occasionally LSSS.

The target categories for scrutiny of acoustic data are common for all vessels participating in the BESS survey, and are given in table 1.

Table 1. Categories used for scrutiny of acoustic data during BESS. The quality code 1 is used for targets species for which a biomass is estimated, while for targets in categories 2 and 3 there is no biomass estimation.

Category	Quality code (LSSS)
Capelin	1 (target)
Herring	1
Polar cod	1
Blue whiting	2 (non target)
Norway pout	2
Cod	1
Haddock	1
Redfish	1
Saithe	2
0-group mixed	3 (others)
Plankton mixed	3
Other scatters	3

Table 2. Overview of vessels and equipment (with technical properties) most commonly used during the BESS.

	Norway			Russia	
	G.O. Sars	J. Hjort	H. Hanssen	F. Nansen	Vilnyus
Frequencies available (kHz)	18, 38, 70, 120, 200, 333	18, 38, 120, 200	18, 38, 120	38, 120	38

Comparison of procedures for scrutinising the acoustic data at IMR and PINRO

Procedures which are common for IMR and PINRO

Data used for echogram scrutiny

- 1-nmi used as Elementary Sampling Distance Unit (ESDU) from the echogram raw files and 5 nmi displayed on screen during scrutiny
- Survey map (current geographical area)
- Trawl data and the distribution of acoustic NASC calculated from catch composition
- CTD data (water temperature profile)

Processing software used for scrutiny

Specialised acoustic processing software which include features such as layer drawing tools, zoom, thresholding, gray colour palette, integration line, window with TS distribution and TS value in mouse position.

Procedure for scrutiny

1. Echogram "cleaning": exclusion of surface reverberation, noise, spikes from integrated seabed and false bottom recordings from the total s_A contribution.
2. Integration of acoustic values starts at 10-12 m below surface, dependent on weather conditions and accordingly surface bubble layer. At the seabed, a bottom margin is applied - 0.2-0.3 m.
3. Drawing of graphical layers and/or boxes based on the features of the echo recordings and taking into account other available information (data from trawls, CTD etc.).
4. Adjustment of dB-threshold to discriminate fish targets from weaker targets.
5. Assignment of s_A values to available acoustic target categories for each layer/box.
6. Set threshold back to default (if needed) and save the results of the scrutiny.
7. Report generation.

The scrutiny is sometimes divided in 2 stages where steps 1-3 are carried out for the entire echogram session, and then steps 4-6 are carried out.

Procedures which differ between IMR and PINRO

At PINRO, scrutiny is done once a day during a survey, and it is done by the chief acoustician in charge. Sometimes, scrutiny does not start before 1 week into the survey in order to establish an impression of the fish composition in the area from the trawl hauls before scrutiny starts. At IMR, scrutiny happens twice a day and the scientific cruise leader is responsible for scrutiny, while the engineer in charge of the scientific equipment is responsible for technical support. In other words, the scrutiny is always carried out by at least two persons.

PINRO applies a bottom dead-zone correction for the winter survey (but not for the BESS), which is not applied by IMR.

PINRO often applies a compensation of ping losses by a coefficient calculated in a special software "Pride". At IMR no such compensation is used in practice, but the issue of lost pings is usually small due to drop keels.

At IMR frequency response is used more actively for target identification than at PINRO, but more frequencies are available on the IMR vessels.

The procedures for calculating distribution of acoustic backscatter from the catch composition in trawls differ between the institutes, but the principles are the same.

PINRO usually applies the FAMAS software for acoustic data processing while IMR applies LSSS.

Practical exercise: comparison of procedures for scrutiny and results between different small groups

Some interesting data for scrutiny had been selected beforehand by PINRO and IMR. The data were from the northern part of the Barents Sea, between 77 and 79 degrees north, where the same target groups are expected to occur on both sides of the border, but where distribution may still be very different. The data were collected at the end of August/beginning of September 2016 during the annual ecosystem survey by RV 'Fridtjof Nansen' and FV 'Eros' respectively. Four teams, 2 from PINRO and 2 from IMR, each with 2 or 3 persons, worked in separate rooms with the data. The software LSSS was applied, which was well known and mastered by all participants.

Scrutiny of the Norwegian data

During the first day, data from IMR were scrutinised. 10 nautical miles had been completed by 3 groups and could be compared, one group could not generate reports due to technical problems. The total integrated s_A per nm was very similar between the three groups showing that the integrated s_A after omitting bad data, false data and noise (but before allocating s_A to target groups) was very similar among the groups (Figure 1).

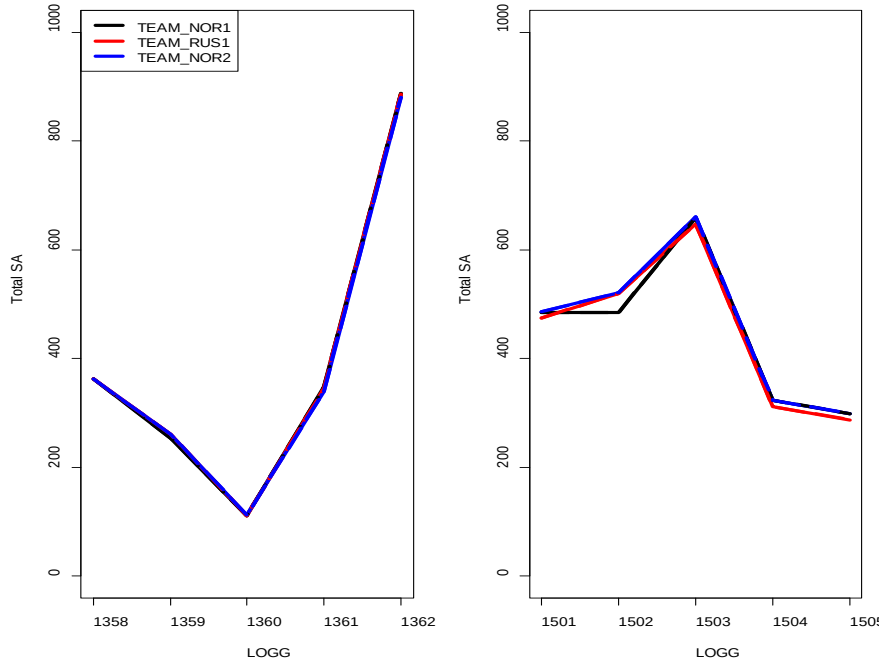

Figure 1. Comparison of total integrated s_A per nmi by the three groups (marked in different colours) for the Norwegian data.

The allocation to acoustic categories was quite different between the groups, in particular for the first 5 nmi (Figure 2). While one group had allocated the majority of the backscatter to capelin for these 5 nmi, one had allocated most to the 0-group category, and the last one had allocated equal parts to polar cod, capelin and plankton. For the last 5 nmi there was a good agreement between the groups about the proportion of s_A allocated to capelin, while two groups had allocated most of the remaining s_A to polar cod, and the last had allocated it to 'other'.

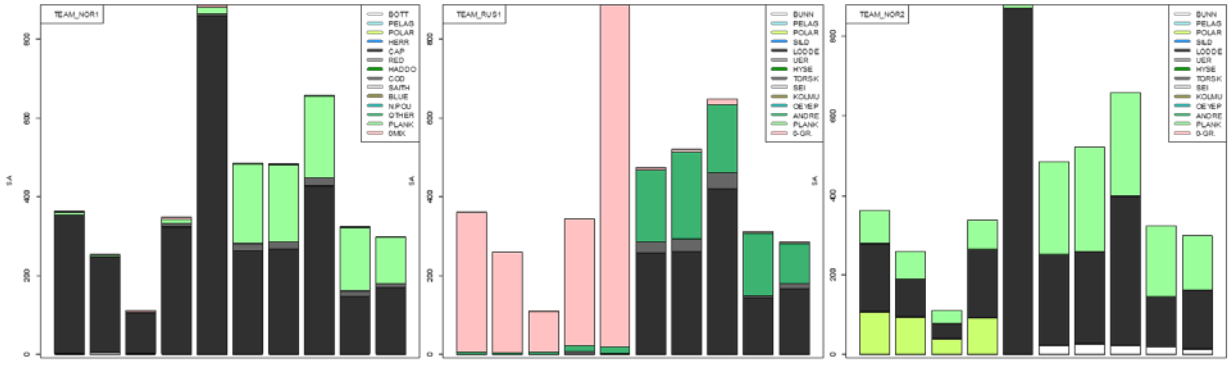

Figure 2. Comparison of s_A-allocation to acoustic target categories (in different colours) for the Norwegian data.

Scrutiny of the Russian data

During the second day, data from PINRO were scrutinised. Scrutiny of 26 nautical miles had been completed by all 4 groups and could be compared. As with the Norwegian data, the total integrated s_A per nmi was very similar between the four groups (Figure 3).

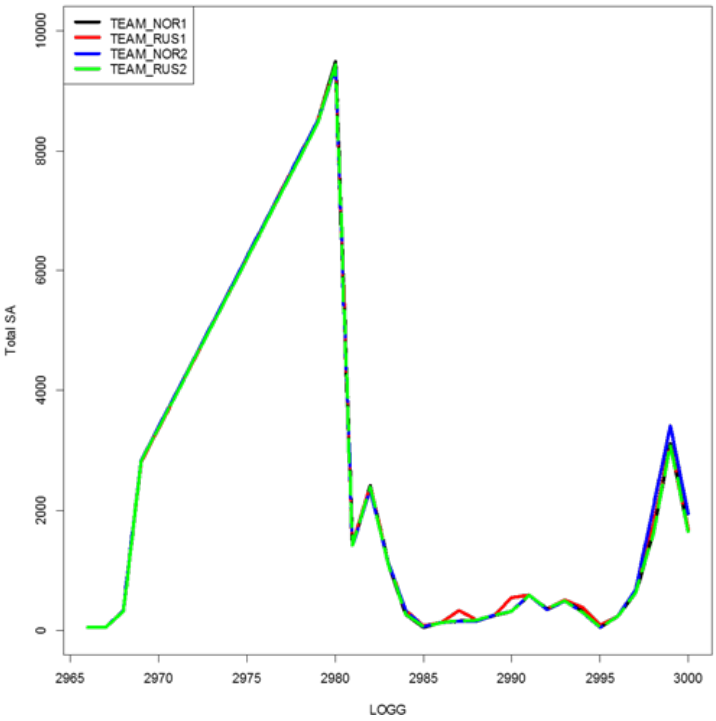

Figure 3. Comparison of total integrated s_A per nmi by the four groups (marked in different colours) for the Russian data.

Unlike for the Norwegian data, the allocation to acoustic categories was quite similar between the groups for the Russian data (Figure 4). All groups had allocated the vast majority of s_A to polar cod which was supported by the catch composition in the trawl hauls. There were some smaller discrepancies, for instance the NOR2 group had used a higher threshold for discriminating plankton from fish so they subsequently allocated more s_A to plankton. There

was also some discrepancy in the last nmi due to a single strong pelagic aggregation which was interpreted differently by the groups, but overall consistency was high.

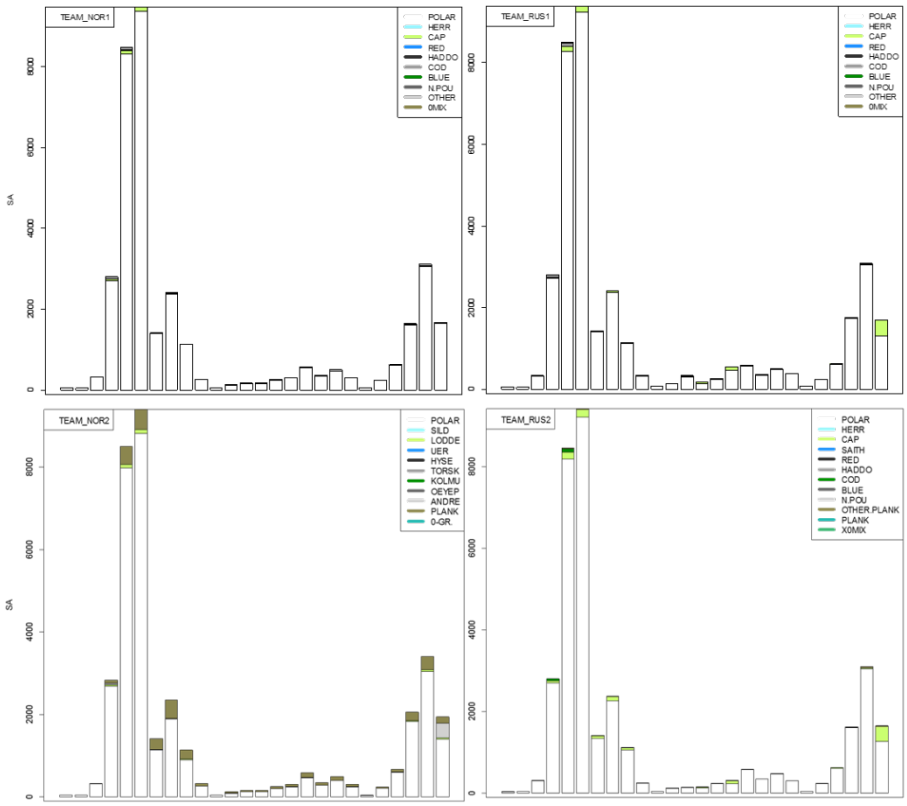

Figure 4. Comparison of s_A-allocation to acoustic target categories (marked in different colours) for the Russian data.

Summary of the practical scrutiny exercise

Two important messages came out of the first day of scrutiny on the Norwegian data: first that scrutiny without information from trawl hauls close by which was the case for the first 5 nmi, is very difficult in these areas. There were very high discrepancies between the groups for these 5 nmi. Second that scrutiny on land long after the survey was carried out, without the impression of the area and associated fish composition, is also challenging.

The scrutiny of the Russian data was more straight-forward, when huge pelagic aggregations are totally dominating the s_A, and the information from trawl hauls points to pure polar cod occurrences, there is not much room for differing interpretations. When polar cod and capelin occur in mixed aggregations, the situation is different, and this has been known for a long time to be a challenging scrutiny situation. Polar cod have not been observed in pelagic schools for several years in the BESS, but reappeared strongly this year, and often in pelagic schools. One must be aware of this in the scrutiny during next years' BESS survey, and the use of multi-frequency techniques for differentiating between these two species should be explored.

The thresholding technique to identify fish from weaker targets was used differently by different groups. A high threshold results in less s_A allocated to fish, and the technique must

therefore be used with caution. The appropriate level of thresholding is also depth dependent, and typically decreases with depth. The routines for thresholding differed somewhat between different operators, but one procedure used by several operators was to threshold until you only see what you want to see (e.g. fish), and then evaluate if you have lost something you should have included.

In the PINRO procedure for scrutiny, “Plankton” is not used as an acoustic category contrary to the Norwegian procedure, the category ‘Other’ is used instead. However, the “Plankton” category is very wide and vague, and the information has in practice low value of use. The plankton which could potentially be discriminated from other targets through scrutiny, is macroplankton, particularly krill, but this requires different techniques which are elaborated further in a forthcoming section of the report.

Summary of the echogram scrutiny workshop

Comparison of procedures for scrutiny between the institutes

An important outcome of the workshop was the confirmation that PINRO and IMR practice the same principles for echogram scrutiny as described in the BESS Sampling Manual. This was demonstrated in the practical work comparing results of the scrutiny between different groups. This is the case even though there has been no meetings or routine exchange of information to standardize the scrutiny procedure between the institutes, at least in recent years. For instance, there is a common understanding of the importance of target trawls and similar use of catch proportion for weighting of the acoustic recordings in mixed aggregations. Both institutes share the philosophy that only targets visible in the acoustic recordings are valid for allocation, so when targets are not visible acoustically they are not contributing, even though the targets are present in trawl catches. The use of layers to discriminate between groups of organisms, ‘box-drawing’ around dense aggregations, as well as on-screen dB-thresholding techniques for discriminating fish from weaker targets were also similar between the institutes. Some of the differences between the institutions clearly arose from the fact that the equipment differed. For instance, did IMR use frequency response more actively for target identification than PINRO, which is quite obvious since more frequencies were available on the IMR vessels (typically 4-6 compared to 1 or 2). Similarly, a correction for bubble attenuation was actively used by PINRO, since the lack of drop keel made bubble noise a bigger challenge on board their vessels. Only one potentially important general difference was revealed, namely the bottom dead-zone correction which is used by PINRO for the winter survey, but not by IMR. This potentially has a significant impact on the acoustic estimate of ground fish and possibly capelin, also during the BESS.

Lessons learned from the practical exercise

It was very evident in this exercise that lack of trawl samples associated with acoustic recordings made the scrutiny very difficult, and when this was the case, there were huge discrepancies between the scrutinising groups (Figure 2).

There is clearly a difference between scrutiny at sea, which is standard procedure for both PINRO and IMR, and on land after the survey which was done during the workshop. It is likely that experience building up during the survey influences the interpretation of echograms. At PINRO they have occasionally waited about a week into the survey before scrutiny of the data starts. They will then have more information available and increased confidence when echogram scrutiny starts.

Ways forward to increase the quality of and the information coming from the scrutiny

Exchange of information

Increased exchange of information between IMR and PINRO will likely help standardising the scrutiny procedures between the institutes and maybe increase the quality of scrutiny. Exchange of personnel between Norwegian and Russian vessels during surveys can be helpful in that sense. In addition, exchange of echogram screen dumps and trawl catch data between Norwegian and Russian vessels should be done regularly when surveying in the same areas. It might also be useful to discuss the BESS scrutiny at the start of the joint Norwegian- Russian capelin assessment meeting. This is time consuming, and should only be done if there are questionable results, such as obvious differences in target allocation on the Norwegian and Russian side.

Technical improvements

The Russians use an acoustic dead-zone correction as standard on other surveys than the ecosystem survey. Since this is not implemented in LSSS now, Norwegians cannot apply such a correction directly. The dead-zone problem can be important, not just for demersal fish, but also for capelin close to the sea bed, and should be discussed further by experts in acoustics for application in the ecosystem survey. If the dead-zone problem is important, the implementation of correction routines should be proposed to the LSSS developers.

All acoustic categories and species must be given names in the system. Exchanged reports must contain English names of acoustic categories. The Russians have a specialised software "SEVERER" for presenting the trawl data, which works very well.

An echogram scrutiny library developed at PINRO

The Russians presented a scrutiny library where echograms of typical registrations of species, target categories or assemblages where stored as echogram pictures, accompanied by nearby trawl catches. The information was sorted by species and time and could be retrieved by a map. We should explore the possibility of a shared RUS/NOR library of this type. This will be useful for standardising the echogram scrutiny between IMR and PINRO. It can also serve as a valuable tool for education of students and new cruise leaders/chief acousticians. Furthermore, the survey manual should include echogram extracts showing typical recordings of different targets from different areas.

Regular scrutiny workshops

A workshop organised in a similar way as this one should be arranged regularly (e.g. each 3rd year). We might need some more time than just two days. Presentation of new technology and software should be included in the workshops.

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